U.S. Naval Med. Sch., Bethesda, Maryland
Fundamentals of X-ray: physics and technique.

FUNDAMENTALS
of X-RAY
PHYSICS and TECHNIQUE

NAVAL MEDICAL SCHOOL
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X-RAY TECHNIQUE

INTRODUCTION

The development of X-ray machines in recent years has been characterized by great improvement as to protection from electrical hazards, increased capacity and numerous automatic adjustments. None the less carelessness may still result in disaster and knowledge is, if anything, more important than ever. There is no such thing as "fool proof" apparatus. All operators of X-ray units should be well grounded in basic principles including biological hazards.

The final report of the roentgenologist is the end result of a long chain of processes each one of which is important and subject to many difficulties. Furthermore, practically all X-ray departments are extremely busy and blunders are costly in time, inconvenience and waste of expensive material. The technician should aim at perfection in technique, a maximum of consideration for the patient and the highest degree of cooperation with the medical officer.

The X-ray or "Roentgen" Ray was discovered by Roentgen in 1895 in the course of systematic investigation of electrical discharges in glass tubes containing highly rarefied gases. His discovery formed a fitting culmination not only to his own labors but also to the work of many brilliant scientists extending back for many years, even to the invention of the vacuum pump in 1650 by Otto von Guericke.

X-ray immediately became the object of intensive study all over the world and was promptly utilized by naval and military surgeons.

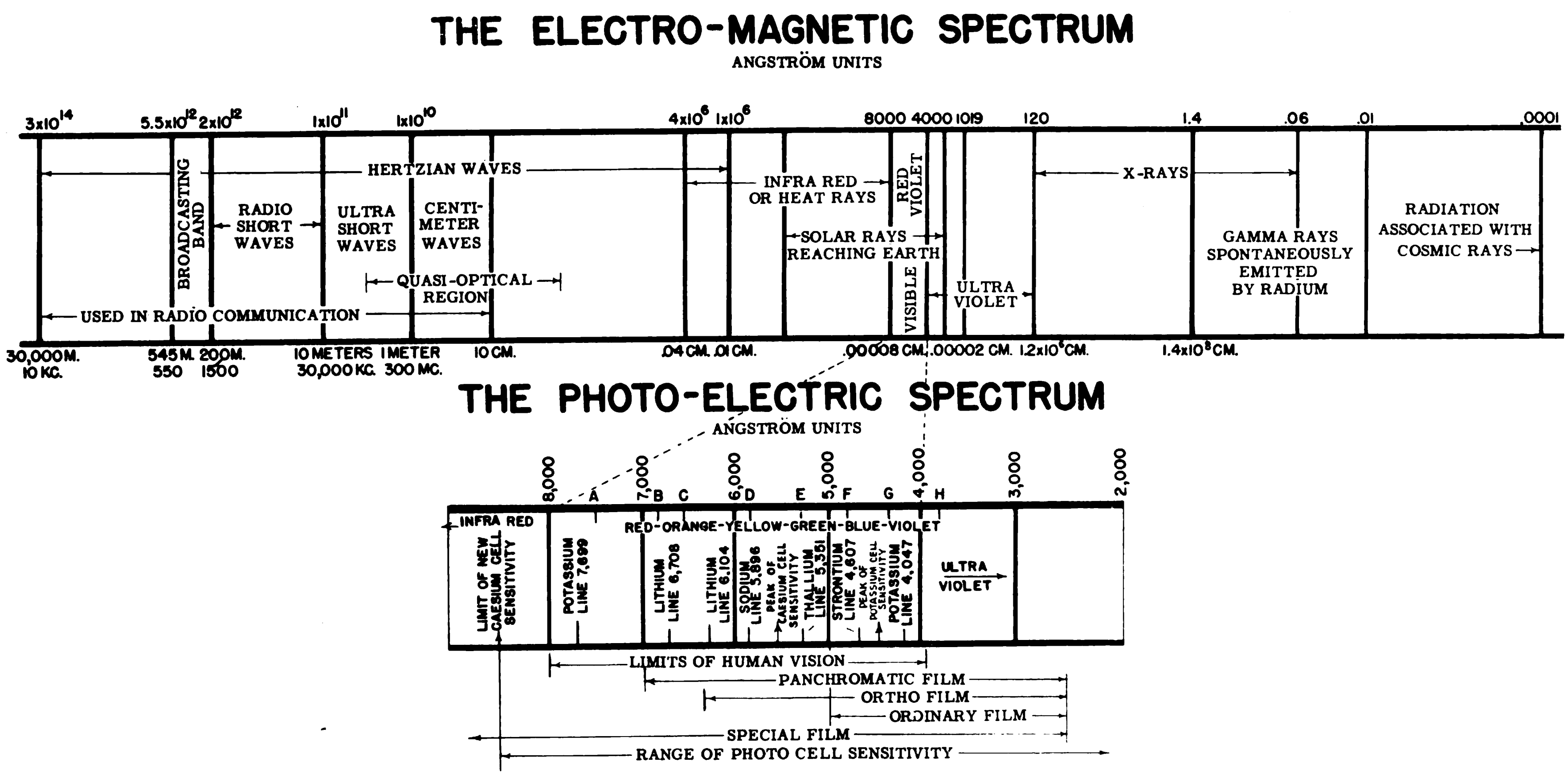
The nature of X-ray was a complete mystery at first but it is now recognized that it is a form of radiant energy forming a band of very short waves in the vast family of electromagnetic waves comprising radio waves hundreds of meters in length, infra-red, visible light, ultraviolet, X-ray, gamma rays of radium and most likely the cosmic rays.

X-ray wave lengths are measured in Angstrom Units (abbreviated A^{o} or A.U.) This unit is 1/10,000,000 of a mm. The range of X-ray wave lengths is usually put at 0.06 to about 136 A^{o} but the useful rays are all less than 1 A^{o}. The rays generated by a tube energized by a current of 100,000 volts potential mostly fall within 0.12 and 0.15 A^{o}.

GENERAL CONSIDERATIONS

ATOMIC STRUCTURE. In order to understand the production of X-ray it is necessary first to learn something of electricity. This includes not only electrical currents and discharges but certain fundamental facts concerning the nature of matter.

Matter, as is well known, is built up of molecules which are the smallest particles of a substance which can exist and still possess the characteristic properties of the substance. The molecules in turn are made of atoms which constitute the smallest units capable of entering into the formation of a chemical compound.

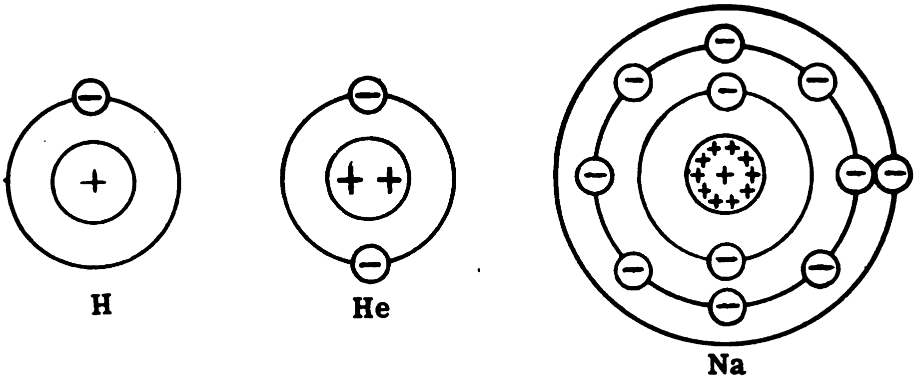


ELECTROMAGNETIC SPECTRUM

Not so long ago, the atom was thought of as a sort of undifferentiated building block, but lately it has been proven that it is a very complex structure built largely of protons and electrons. The former are heavy, positively charged and form the bulk of the nucleus or core of the atom. The electrons, negatively charged, are about 1/1800th mass of the proton and are found both within the nucleus and without.

The nuclear electrons are joined with protons to form neutrons. The outer electrons revolve in orbits much as the planets spin about the sun and so are called orbital electrons. The electrons constitute the negative particles of electricity. The number and arrangement of the various electric particles are what determine the nature and behavior of the atom and consequently each element. The number of electrons in the atomic orbits varies from one in the case of hydrogen to 92 in the case of uranium. Normally the positive charges of the protons are exactly balanced by the negative charges of the electrons and the atom is then neutral.

The following diagram will show how the orbital electrons are thought to be arranged in certain of the atoms.



ELECTRON CONFIGURATION OF SOME ATOMS

The electrons are thought to be all alike regardless of source and to possess the same negative charge. They are able to exist and move independently of the parent atom. Thus they may be torn from one body and piled on another. When such happens the atom which has lost electrons will naturally show a positive charge and the atom which has gained electrons will be negatively charged. Bodies so charged will attract each other due to the stress which seeks to restore equilibrium. If these bodies are connected by a conductor the electrons will flow back to the positively charged body. This flow constitutes the electric current.

Substances vary enormously in the ease with which they can transmit a flow of electrons. Most metals such as copper, silver, gold, aluminum and mercury are good transmitters and are called good conductors. Glass rubber, mica and various plastics are very poor conductors and are called insulators. The difference in conductivity probably depends on how firmly the orbital electrons are held. When the orbital electrons are difficult to dislodge, the substance characterized by this property will tend to block any free flow of electrons and so constitute an insulator.

When a sufficient number of orbital electrons are loosely held, the substance so characterized will possess a sort of atmosphere of electrons which are susceptible to motion under stress of an electrical charge. Such a substance will naturally be a good conductor.

A partial list of conductors and non-conductors:

Conductors	Insulators
Silver	Slate
Copper	Oils
Aluminum	Porcelain
Zinc	Dry leather and paper
Brass	Wool and silk
Platinum	Sealing Wax
Iron	Sulphur
Nickel	Resins
Tin	Shellac
Lead	Ebonite
Antimony	Mica
Mercury	Paraffin Wax
Carbon	Glass
	Various plastics

The flow of electricity in a metallic conductor is thus based on the free flow of electrons through it. Since the positive charge resides on the large heavy nuclear part of the atom, such positive charges do not move readily in solids. Consequently the flow of electricity through metals is due solely to electrons in motion, and obviously the direction of motion is from the negative terminal to the positive. This direction is exactly opposite to the convention adopted many years ago, that electrical current flows from positive to negative.

The strength or force with which the electrons seek to rush from a negatively charged body to one positively charged is called difference of potential or electromotive force (E.M.F.) and is measured in units called volts.

The amount of electrons that flow through a conducting substance is measured in amperes. The resistance of a substance to the flow of electrons is measured in ohms. These units are defined in terms of each other as follows:

A volt is the amount of E.M.F. that will cause 1 ampere of current to flow against the resistance of 1 ohm.

An ampere is the amount of current that will flow against the resistance of 1 ohm with a pressure of 1 volt.

An ohm is the amount of resistance that will require a pressure of 1 volt to cause a current of 1 ampere.

The mathematical relation between these units is expressed by Ohm's law:

E.M.F. in volts = Resistance in ohms x current intensity in amperes; or more simply E = R.I. Naturally the same law can also be expressed by $R=\frac{E}{I}$ and $I=\frac{E}{R}$.

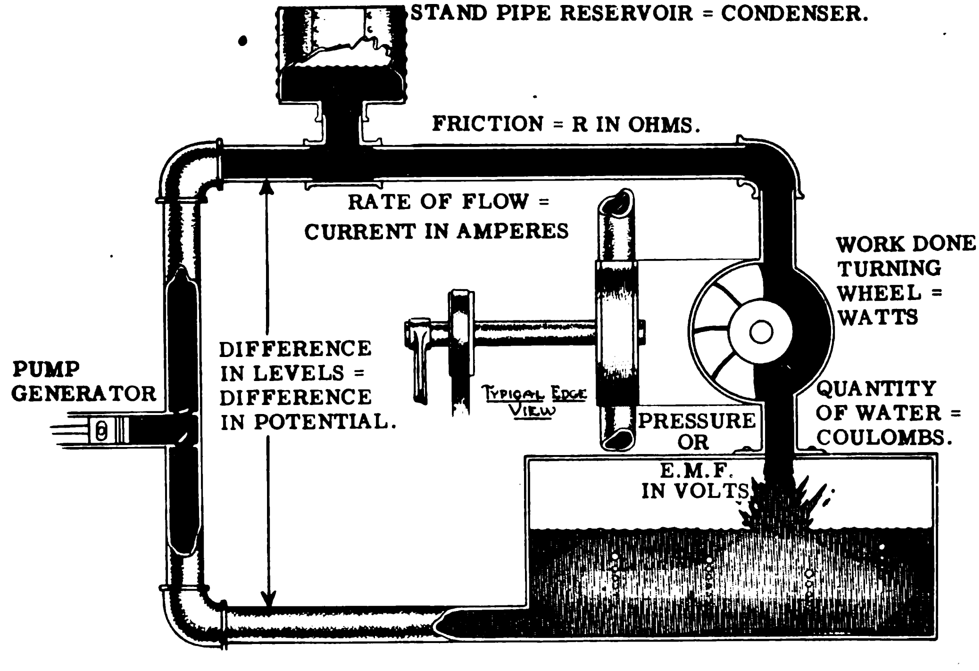
The unit for total quantity of electricity is the "Coulomb" which is 1 ampere maintained for a second. The rate of work or expenditure of electrical energy is measured in watts, one watt representing the work from 1 ampere at 1 volt E.M.F. The product of watts and time (usually in hours) gives the electrical energy consumption. At times these units are too large or too small for certain types of electrical currents so that other terms are in common use. Thus a kilovolt (Kv. or Kv. P.) is 1000 volts and a kilowatt is 1000 watts. A milliampere (M.A.) is 1/1000th ampere.

Because of the abstract nature of electric units, illustrative comparison is usually made between electricity in wire and water in a pipe.

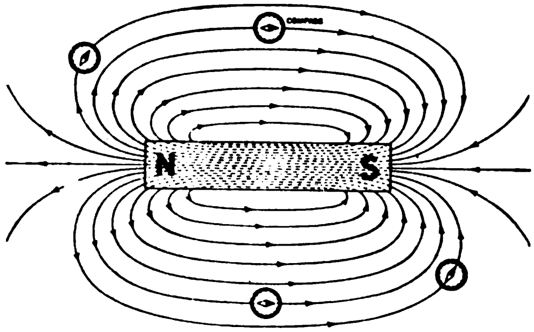
Thus:

Water pressure resembles voltage; the amount of water flow resembles amperage; the resistance to flow imposed by friction and the size of the pipe opening is analagous to electrical resistance.

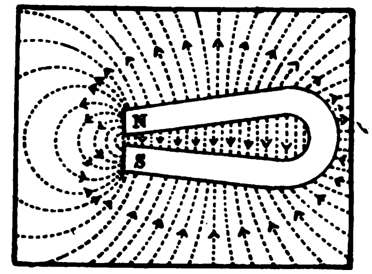
This picture aids considerably in understanding many phases of electrical behavior with one important exception. In the case of water pipe there is nothing of moment that transpires about it whereas in the case of a wire conducting electric currents, electromagnetic lines of force are set up about it similar to those set up by a magnet.



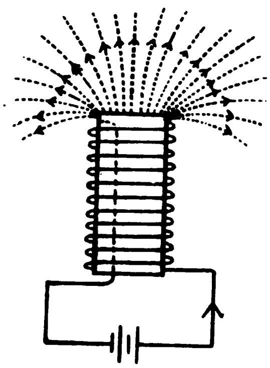
WATER ANALOGY



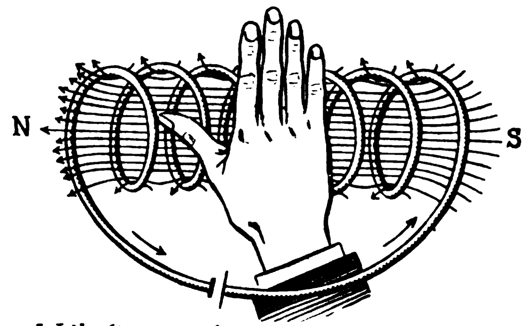
BAR MAGNET.



HORSESHOE MAGNET.

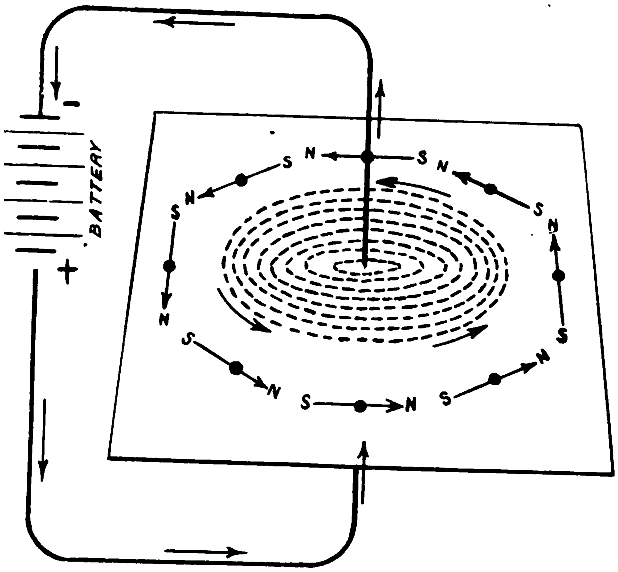


SOLENOID

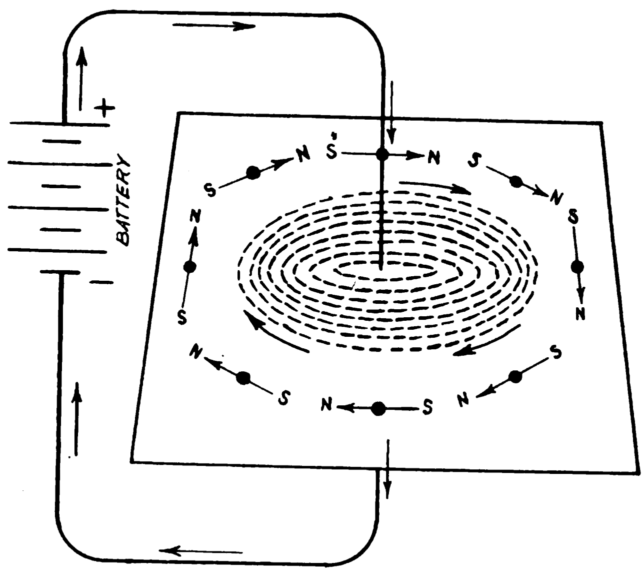


With fingers in direction of current flow, thumb points to north pole.

HELIX (RIGHT HAND RULE).



CURRENT UP - WHORLS COUNTERCLOCKWISE



CURRENT DOWN - WHORLS CLOCKWISE

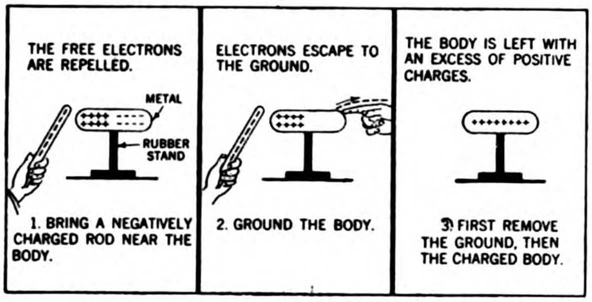
MAGNETIC FIELDS

Production of Electrical Charges and Currents.

In the nature of things, atoms and the objects they make up tend to be in a state of equilibrium. If we wish to change this by producing a charge or a current, we must interfere, i.e., we must apply energy in some suitable manner as by friction, chemical reactions, and mechanical means employing electromagnetic induction.

1. Friction: The ancient Greeks observed that amber (which they called elektron) when rubbed would attract light objects such as bits of paper. What happens is that when certain dissimilar substances are rubbed together electronic migrations are caused thereby producing charges. Charges thus produced are spoken of as static electricity. Glass rubbed with silk acquires a positive charge. Sealing wax or hard rubber rubbed with a dry cloth acquires a negative charge. Like charges repel each other. Unlike charges attract each other.

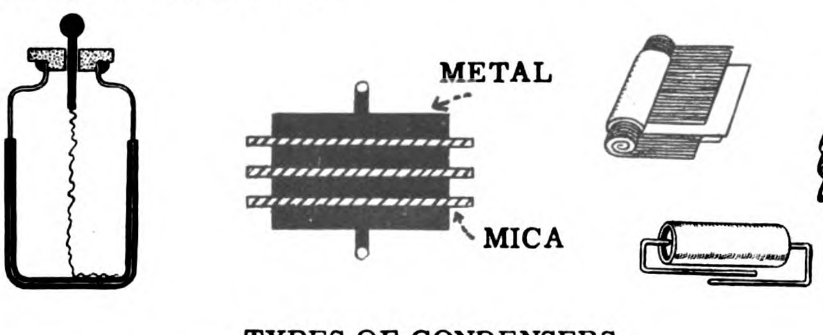
Induction: When a positively charged body comes close to a neutral object, electrons are pulled toward the end of the object nearest the charged body and the object thus becomes negatively charged at this end and if sufficiently light will be pulled into contact. When a negatively charged body is brought near a suitable object a positive charge will be induced by repulsion of electrons.



CHARGING BY INDUCTION

Condensers: These are analagous to storage tanks and consist simply of metal plates separated by insulating material such as glass or mica. They are used to store up charges to the limit of their capacity. The store of electrical energy can then be discharged when desired.

LEYDEN JAR



PAPER CONDENSER

TYPES OF CONDENSERS

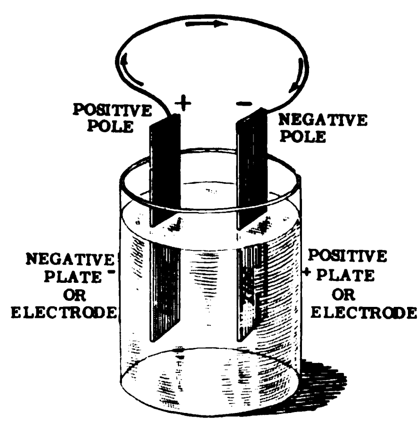
The unit for measuring condenser capacity is the Farad which is a capacity of such degree that a charge of 1 Coulomb will produce a 1 volt difference of potential. This unit is so large that in practical work the unit used most is the micro-farad or 1/1,000,000th Farad.

Static electricity was formerly much used, the electric charges being generated by whirling glass plates. Since such machines are almost entirely of historical interest no discussion of them is included.

2. Chemical Generation of Electricity: When plates of two dissimilar metals such as copper and zinc are placed in dilute sulphuric acid, zinc particles will go into the solution as positively charged "ions" which repel positively charged hydrogen ions toward the Cu plate where they appear as free hydrogen atoms. The Cu plate becomes positively charged and the Zn plate negatively - due to loss of positive Zn ions.

If the Cu and Zn plates are connected by a wire a current will flow due to the difference in charges. This is the galvanic current.

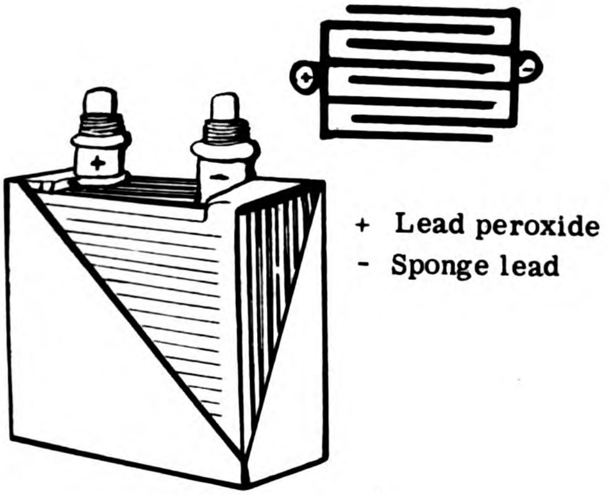
A combination of suitable solution (called an electrolyte) and two metals is called a Galvanic or Voltaic cell, wet cell or wet Battery. They are not extensively used.



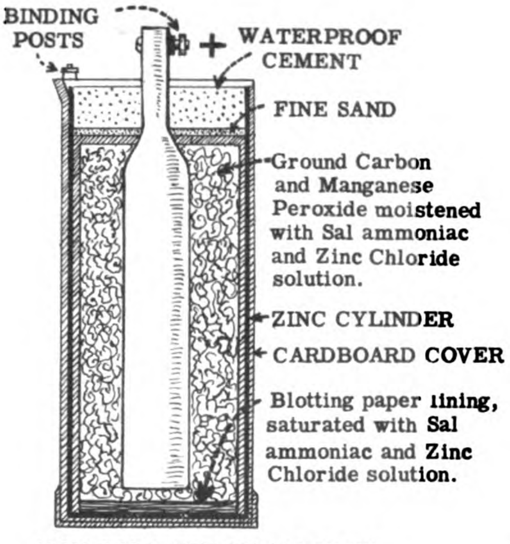
NOMENCLATURE OF A VOLTAIC CELL (Conventional Current Flow)

Dry cells consist of a zinc container filled with a paste of amonium chloride, manganese dioxide and granulated carbon. In the center is a carbon rod. The top is sealed with pitch. Terminals are placed on the zinc casing and the carbon rod. The ordinary dry cell produces about 1.5 volts, E.M.F. For some purposes large batteries of 45 or more volts are built by combining numerous cells. Dry cells are, of course, in constant use to supply current for a variety of purposes, such as door bells, signaling devices, radios, flashlights, etc.

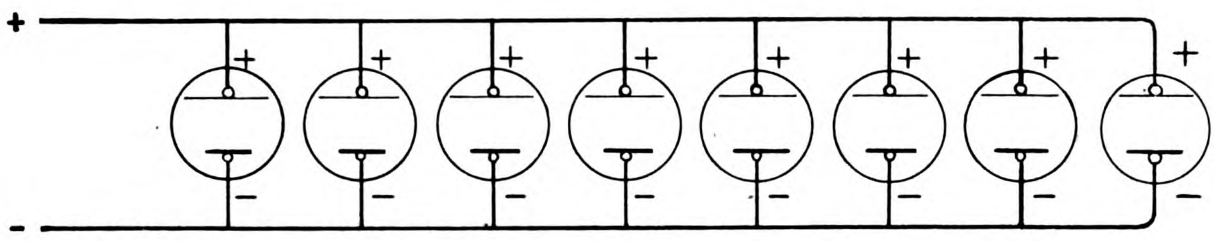
When a number of cells must be connected together to obtain the desired current, it is necessary that they be connected correctly. When a group is connected carbon to zinc they are said to be in series and the resulting voltage will be the sum of the voltages of all the cells. The maximum amperage is that of one cell. When they are connected zinc to zinc and carbon to carbon, they are said to be in parallel. In this case the voltage is that of one cell and the maximum amperage will be the sum of all.



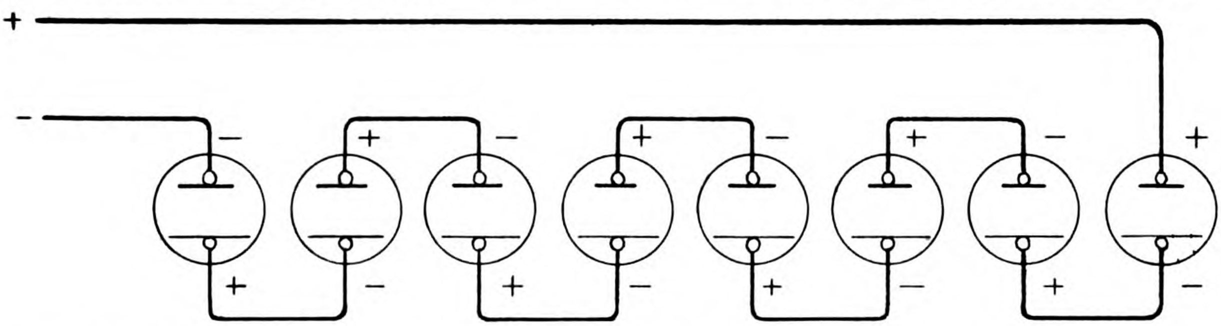
Storage battery cell



DRY CELL, SECTIONAL VIEW



EIGHT CELLS CONNECTED IN PARALLEL FOR MAXIMUM CURRENT

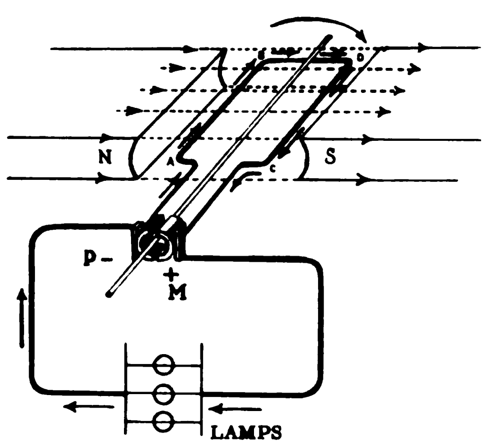


EIGHT CELLS CONNECTED IN SERIES FOR MAXIMUM VOLTAGE

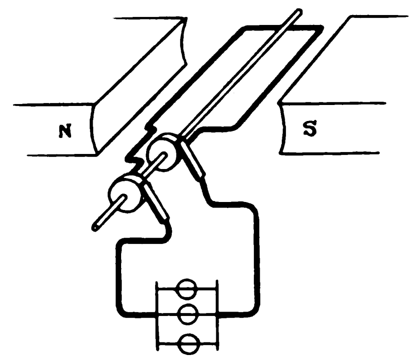
A storage battery is a group of special type cells (usually three) connected in series. The plates are usually of lead and certain of its compounds; the electrolyte, dilute sulphuric acid. They can be charged by devices operating on line current whenever necessary, and furnish a low voltage current of high amperage.

3. Mechanical generation: This is made possible by electromagnetic induction.

About all magnets and about wires carrying electric currents there are electro-magnetic lines of force. When a wire loop forming a complete circuit cuts through such lines of force an electric current will be induced. By using powerful electro-magnets and specially wound coils of insulated wires which rotate rapidly in the magnetic field, huge outputs of electric current are obtainable in either direct or alternating forms. The apparatus used to accomplish this is called a dynamo. As we all know dynamos are the main source of electrical currents used in our daily lives.



SIMPLE D.C. GENERATOR

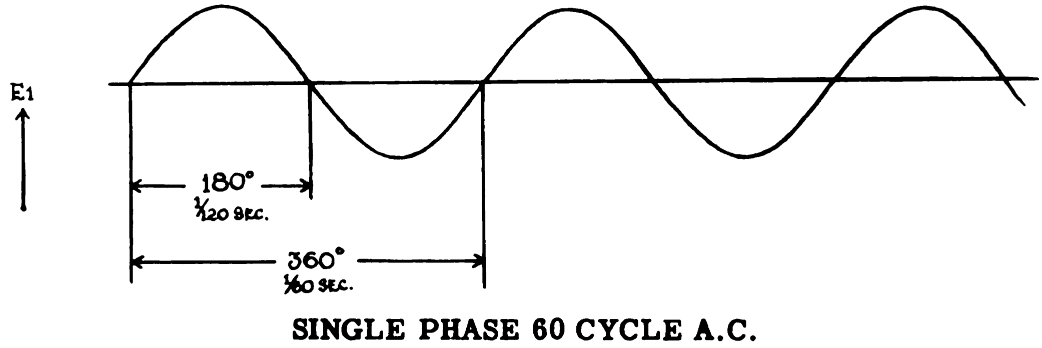


SIMPLE A.C. GENERATOR.

When the current from a dynamo is collected from a slip ring device it will be alternating. To obtain direct current it is necessary to employ a segmented ring, each segment insulated from the other. This device is known as a commutator.

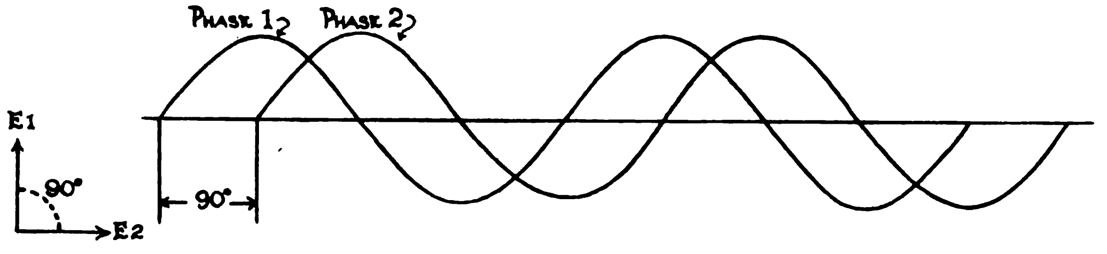
It is to be remembered that the D.C. current from a dynamo is not entirely even like that from a battery. It will show a number of minor fluctuations corresponding to the number of segments on the collecting ring. In other words, there are unidirectional pulsations producing a finely rippled wave form.

Possibilities do not end here as alternating current may be varied as to number of phases. To make this clear, let us consider first ordinary A.C. current from a simple dynamo; this will be "single phase" and is conventionally diagramed as the so-called sine wave. Frequency is usually 60 cycles per second.

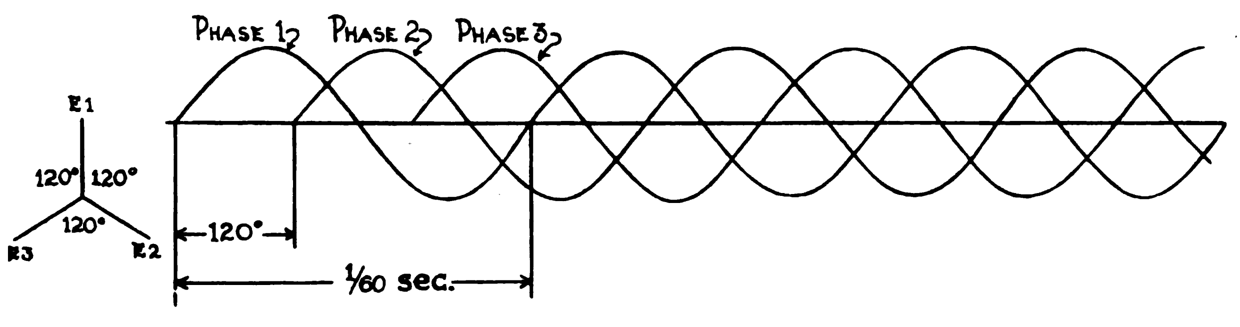


SINGLE PHASE 60 CYCLE A.C.

By appropriate design of the armature it is possible to start one or two additional waves of A.C. currents at different points in the original cycle, thus producing two or three phase current as the case may be.



TWO-PHASE A.C.



THREE-PHASE A.C.

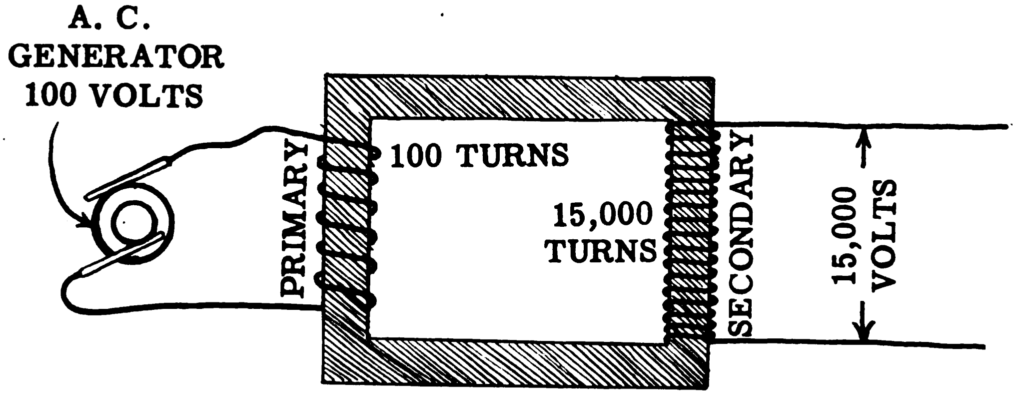
The purpose of multiple phase current is smoother flow of power and in the case of X-ray, as will become apparent later, a closer approach to "constant potential".

So much for sources of electric current. In order to obtain the various voltages needed, induction is again made use of. If a bar or ring of soft iron has two different coils wound on it, one coil consisting of a few turns of thick wire and the other of many turns of fine wire, then when alternating or rapidly interrupted direct current is sent through one coil, a current will be induced in the other, the voltage of which will be in the same proportion to the original or primary current as the number of turns of wire in the respective coils. These appliances are called transformers.

The iron core plays a most important part and is an absolute essential. Without it a coil of wire becomes a simple helix through which a current will flow with practically no resistance except inherent ohmic. When an iron core is in place however, impeding counter currents are set up which act to stop or choke the flow in the primary circuit and produce fluxes of electromagnetic lines of force. These serve to divert the electrical energy into the secondary. Without the presence of the counter E.M.F. or impedance it is obvious that we would have largely "short-circuit" effects and comparatively little induction.

In general induction occurs as the lines of force are built up and collapse with the "making" and "breaking" of the circuit in the case of interrupted direct current or with the reversals of alternating current.

It might also be noted that the impeding or choking effect mentioned above is made use of in regulating current strength. A simple coil with a movable iron core is placed in the circuit. By varying the position of the core the amount of current will be altered. When the core is completely within the coil comparatively little current will pass due to impedance. When the core is largely withdrawn the current strength will be increased due to lack of impedance. This type of coil is known as a "choke coil" and is used most frequently to regulate filament currents.



A STEP-UP TRANSFORMER

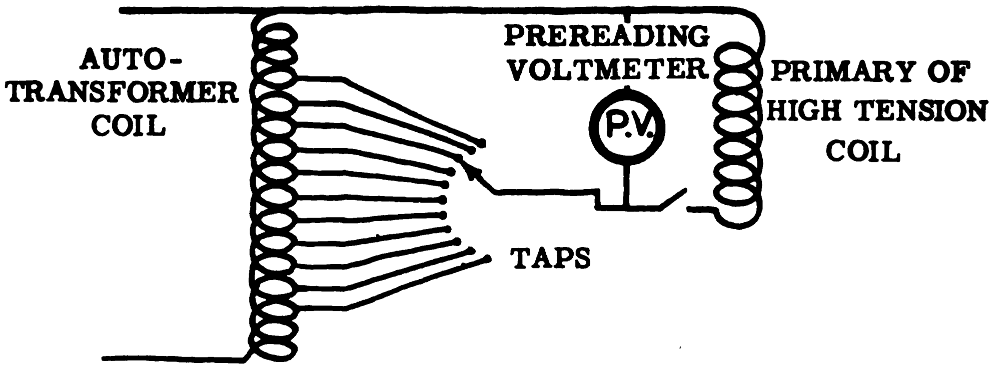
To change D.C. to A.C. current, motor generators or rotary converters are used. To change A.C. to D.C. rectifying vacuum tubes are commonly used, though converters may also be used.

In use of apparatus it is always important to know the type of current it is designed for. Apparatus designed solely for A.C. will not operate on D.C. and may be ruined by it. Furthermore A.C. apparatus must be operated on the frequency for which it is designed.

The transformers used in X-ray apparatus are of three types. (1) Step-up, (2) Step-down, (3) Autotransformers. The step-up transformer has already been illustrated. The step-down transformer is simply the reverse of the step-up type; the primary coil has numerous turns and the secondary few so that a reduced voltage is obtained.

Transformer windings must be well insulated and in the case of high tension types the entire transformer is usually submerged in a tank of dehydrated oil.

The autotransformer is another means of obtaining varying voltages from the incoming current. It has but one winding which serves as both primary and secondary. The windings are tapped at a number of points so that a varying number of turns may be utilized for the secondary circuit. The ratio of these turns to the entire number of turns will determine the voltages in the secondary. Thus by means



DIAGRAMMATIC SKETCH OF AN AUTOTRANSFORMER

of the autotransformer, various voltages may be applied to the high tension step-up transformer and so regulate its output. The autotransformer taps are connected to studs of a multiple point switch. Between each of these studs a "dead" or unconnected stud is always present to prevent the switch from shorting out two line studs, thus causing a short circuit which may burn out the autotransformer or do other damage.

It will occur to many here that a coil of high resistance wire with a sliding contact could also be used to cut down the primary current for X-ray purposes. This type of apparatus is called a rheostat and,of course, could be used. The drawback is that the rheostat wastes energy by marked heat production and where considerable reduction of incoming voltage is necessary, both the loss of energy and the production of heat are too serious. Ordinarily a rheostat is used only to supplement the autotransformer for the purpose of fine gradation.

The high tension transformer for X-ray apparatus often has about a 1000 to 1 ratio. Each volt of the primary would thus result in 1000 volts in the secondary. Amperage is correspondingly reduced. If 10 amperes flow in the primary, 0.010 amperes (or 10 milliamperes) will flow in the secondary. It can thus be seen that a transformer produces no energy, it merely changes its form. As a matter of fact some energy is always lost due to electrical resistance and various factors.

The voltages used in usual clinical radiography range from about 30 to 90 K.V.P. Industrial radiography of metal castings, etc. calls for voltages up to 400 or more K.V.P. X-ray therapy usually calls for range of voltage from about 100 to 200 K.V.P. However, voltages of from 400 to 1,000 K.V.P. are being used.

The step-down transformer is used to produce voltages of from 10 to 18 for filaments in X-ray and valve tubes.

X-RAYS AND X-RAY MACHINES:

With the foregoing in mind we are in a better position to take up the actual production of X-rays.

First let us consider what happens in the earliest type of tube. These tubes contain a very small amount of gas and so are spoken of as gas tubes. When a high tension E.M.F. is applied to such tubes, the stress of this very high voltage liberates electrons from the atoms of gas. Due to the extreme repulsion consequent upon the high voltage, these electrons are hurled from the cathode in a heavy, high velocity stream which is called the "cathode ray" and thereby forms an electric current through the tube. These electrons necessarily are suddenly stopped by the wall of the tube or an interposed target and just as marbles thrown on a drum head will cause sound waves, so these electrons will set up an analagous disturbance in the form of the very short waves which we know as X-rays. In the earliest tubes the electrons simply hit the glass wall of the tube in a large spot and produced feeble scattered X-rays. When much energy was used the glass would heat, soften and give way ruining the tube. This was largely because, unfortunately, only a small amount (possibly less than 1%) of the energy of the electrons is converted into the energy of X-ray, the rest appearing as heat. Thus in a short time platinum and later tungsten targets were interposed and these targets were conveniently used also as the anode. The cathode was made convex so as to focus the electrons on the target both to prevent waste by scattering and to have a smaller spot from which X-rays emanated. The smaller the spot the sharper the radiograph. Gas tubes were used for a long time and good work was done with them. However, they were exceedingly "cranky" as minute variations in gas content caused marked changes in current and hence X-ray characteristics. The less the gas, the lower the milliamperage, the higher the voltage and the shorter the wave length of X-ray, the greater is its penetration and vice versa.

The modern "hot cathode" type of tube is based on the fact that when metals are heated to incandescence they give off clouds of electrons much as a kettle of boiling water emits steam. Thus it is possible to use a heated filament in the cathode as a source of electrons to carry current across a tube instead of relying on electrons from highly rarefied gas. Further, since the current intensity that can be sent through the tube depends on the free electrons available and since these in turn vary with the degree to which the filament is heated, we can readily control the tube current merely by varying the current which heats the filament. A prerequisite is a practically complete vacuum; otherwise the gas will complicate matters and interfere with control and focus of the cathode stream. A hot cathode tube that has accidentally acquired gas is spoken of as "gassy" and more than an exceedingly minimal amount of gas will ruin such a tube. These tubes were developed by Coolidge and are often spoken of as "Coolidge Tubes".

The capacity depends very largely on ability to disperse heat, since, as already noted, nearly all the electrical energy is converted into heat. Thus a fundamental feature of all tube design is some means of disposing of the excess heat.

In the old universal Coolidge tube with a solid tungsten target, heat radiation from the target is depended on. The target, under condition of heavy radiation, becomes heated to the point of glowing and thus radiates heat effectively. A large glass envelope is used to aid in cooling and also prevent breakage from heat; it is thus a constant feature of these tubes.

A glowing anode is, of course, most objectionable with unrectified current as

it will emit electrons which in turn will be thrown against the tube walls and so cause strain, damage the tube and also produce scattered radiation. To remedy this, designers produced a radiator tube. Here a button of tungsten is placed in a solid block of copper which conducts the heat to a finned radiator at the anode end of the tube. Occasionally the anode end is water jacketed. The glass envelope is considerably smaller.

In the case of shock proof tubes which are usually completely immersed in oil, the oil carries off the heat from the anode. This method is not always enough for some heavy duty tubes and so we will at times find an oil immersed assembly cooled by running water; or again, as in the case of deep therapy tubes, the oil will be circulated through a cooling device. Finally, a blower may be used at the anode end possibly combined with a device to circulate the oil in the tube head.

Another factor related to tube capacity is the size of the focal spot. Very high energies applied to a small spot will tend to blast a hole in the target. Thus higher capacity tubes must have larger focal spots unless the target is a rotating disc (rotating anode tube).

A final consideration governing capacity is the filament. Filaments are designed for certain specific energy ranges. These can be exceeded only by overheating the filament. Naturally, if this is done to any considerable extent, the filament will soon burn out thus reducing tube life.

The energy applied to tubes embraces factors of M.A., time applied and potential across the tube or K.V. Capacity and cooling charts are available for each type tube to indicate limits in this regard and should be referred to without fail.

Characteristic properties of Cathode Rays.

1. The cathode ray is a stream of electrons emitted from the cathode at high speed (from 1/10th to the full speed of light).

2. Each electron has a mass of 9.03×10^{-28} gram.

3. The cathode ray travels in straight lines and can be focused by means of a properly designed concave cathode.

4. Cathode rays have kinetic energy and when suddenly stopped produce heat and X-rays.

5. They can be deviated by electromagnetic fields (toward the positive).

6. They have slight ionizing power.

7. They can affect the photographic plate.

8. They produce fluorescence of certain crystals.

9. They penetrate matter to some degree up to the limit of a few cm. of Aluminum but fall far short of X-ray in this regard.

Characteristic properties of the X-ray.

1. They are radiated in straight lines from the point of origin.

2. They penetrate all substances, some to a marked extent. The greater the atomic weight, the less the penetration and vice-versa.

3. They cause fluorescence of certain crystals.

4. They affect the photographic plate to a marked degree.

5. They produce secondary radiation of X-rays when they strike objects.

6. They ionize gases.

7. They have the same speed as light.

8. They are not reflected nor refracted by the usual Optical apparatus.

9. They are not deviated by electromagnetic fields.

10. They cause irritation of living cells and in excessive amounts, necrosis.

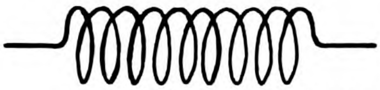
The high tension transformers are activated by alternating currents (usually 60 cycles per second). Accordingly the high tension current in the secondary circuit is also of alternating type. It is possible to neglect this with some types of modern tubes when used at capacities not too great. This is because the X-ray tube can only permit the current to flow in one direction. The reason for this is, of course, that only at the cathode, which has a heated filament, will there be electrons to carry the current. The anode being cold under proper operating conditions has no free electrons to carry current across the gap of the tube. Of course, if the anode is grossly overheated due to exceeding capacity it will then permit current to reverse. Then electrons will be scattered from the anode in large quantities producing scattered X-ray and subjecting the tube to increased strain.

The method of generating X-ray direct from unrectified current is spoken of as self rectification.

X-ray tubes functioning as their own rectifiers should be furnished with a cooling system at the anode to carry away the heat generated by the impact of electrons. The cooling may be accomplished by employing an anode material of high heat conductivity (usually Cu) together with the use of a radiator, or water-jacket attached externally to the anode stem or again by means of oil. In any case the load that can be carried by a tube is definitely limited and this limit should not be exceeded. Otherwise the anode may become incandescent as noted above with serious possibility of trouble.

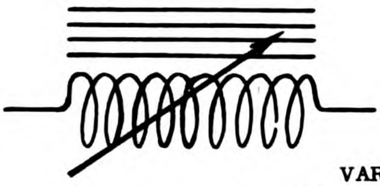
From the foregoing it may be noted that in a self-rectified unit the X-ray tube serves two purposes, i.e. (1) Generation of X-rays; (2) Suppression of every other half cycle.

SYMBOLS IN ELECTRIC CIRCUITS

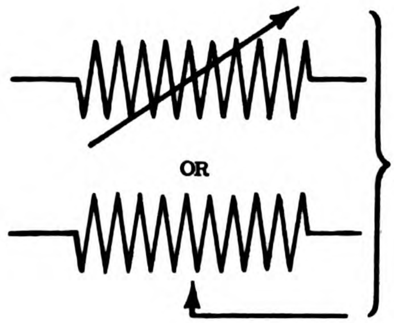


FIXED INDUCTION COIL

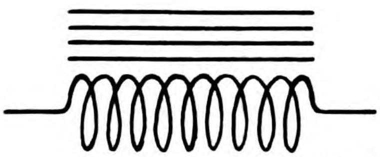
RESISTANCE



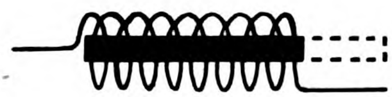
VARIABLE
INDUCTION COIL



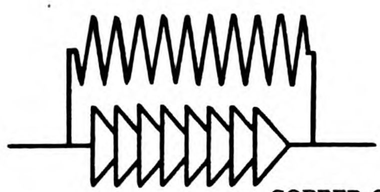
VARIABLE
RESISTANCE



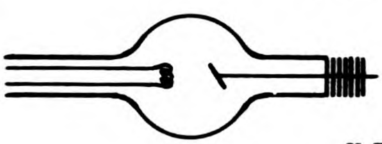
INDUCTION COIL
WITH SOFT IRON CORE



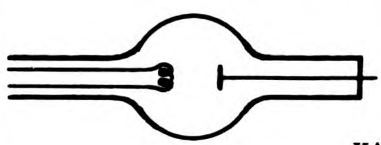
CHOKE OR
RETARDATION COIL



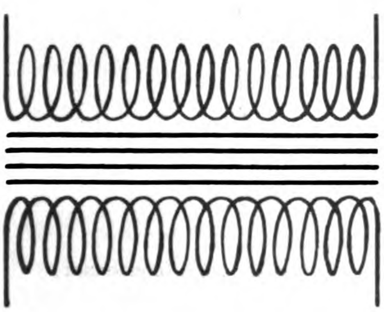
COPPER OXIDE RECTIFIER
WITH SHUNT RESISTANCE



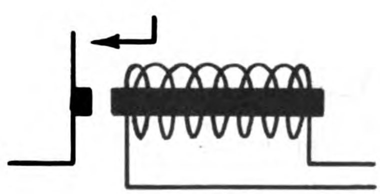
X-RAY TUBE



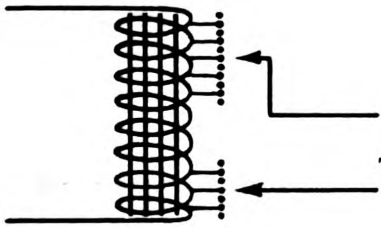
VALVE TUBE



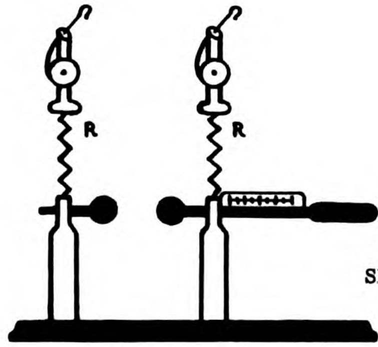
POWER
TRANSFORMER



RELAY

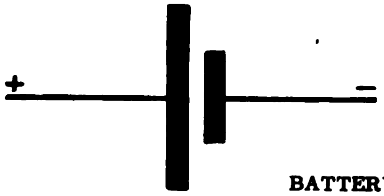


AUTO
TRANSFORMER



SPHERE GAP

SYMBOLS IN ELECTRIC CIRCUITS



BATTERY (single cell)

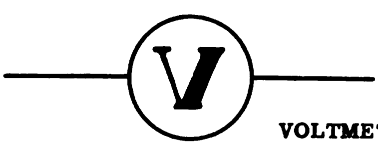
BATTERY
(two or more cells in series)

SINGLE POLE SWITCH

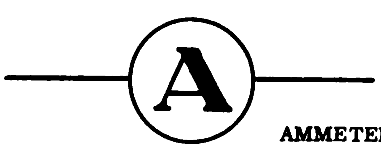
TWO POLE SWITCH

LINES WITH FUSES

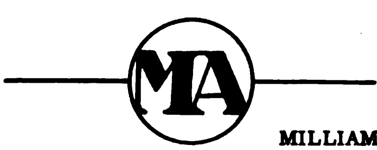
GROUNDING CONNECTION



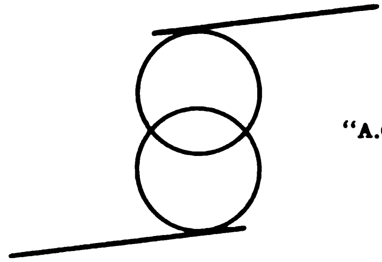
VOLTMETER



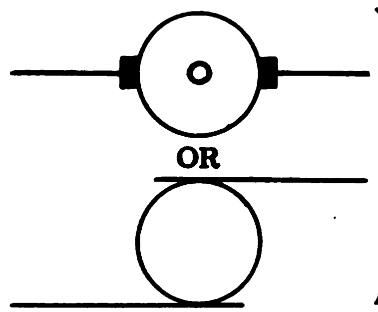
AMMETER



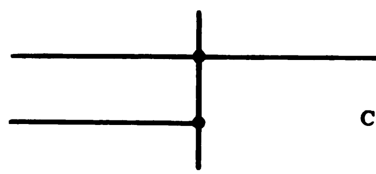
MILLIAMMETER



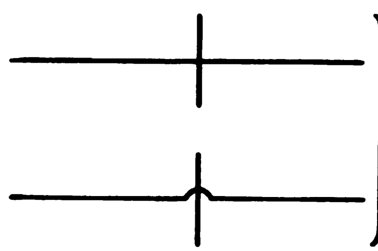
"A.C." GENERATOR



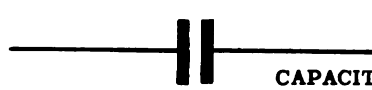
"D.C." GENERATOR



CONNECTED WIRE

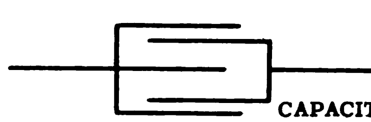


CROSSED WIRES

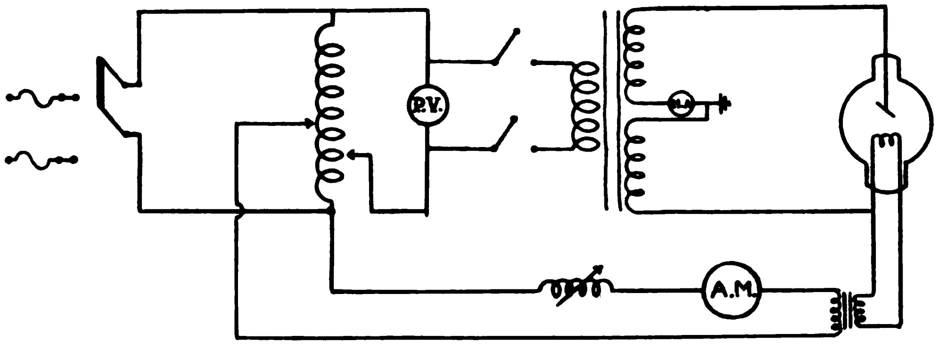


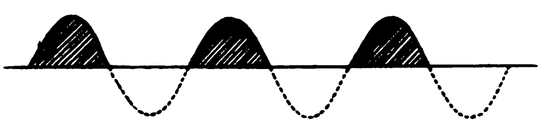
CAPACITANCE (condenser)

VARIABLE CONDENSER



CAPACITANCE CONDENSER





SELF RECTIFICATION
(Half Wave)

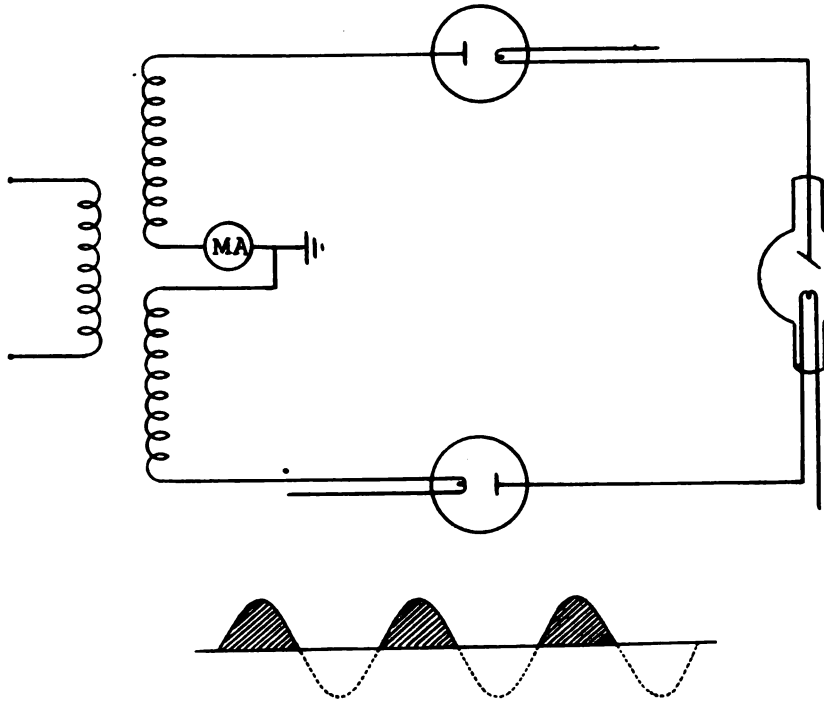
For greater efficiency it is better to have a means of rectification other than that of the tube itself. This rectification may be in the form of a mechanical disc rectifier or valve tubes, which are interposed between the high tension transformer and the X-ray tube. This converts the A.C. to pulsating D.C. before it reaches the X-ray tube.

Mechanical rectification is by means of a rectifying disc rotated at the synchronous speed by means of a synchronous motor.

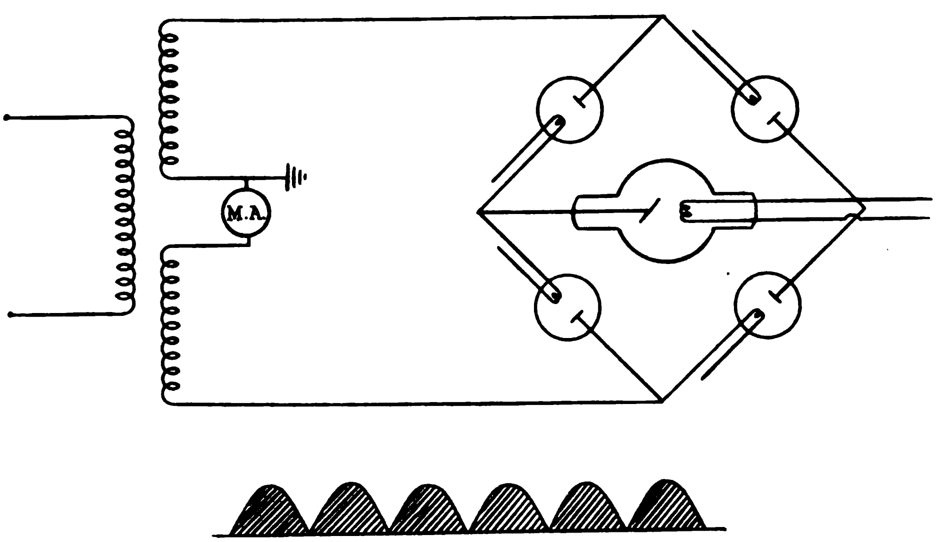
A valve rectifying tube is a vacuum tube having two electrodes, one of which is a heated filament, the other a plate or cylinder of metal surrounding the filament. The heated filament will permit the passage of half of each cycle. The cold electrode will prevent passage in opposite direction. One or two valve tubes will produce half wave rectification. Four valves are best for complete rectification of single phase apparatus; six valve tubes are needed for three phase machines.

From the diagram it will be noted that the voltage is not entirely uniform but in impulses which rise to a peak and then fall. The top voltage is spoken of as the kilovolt peak or K.V.P.

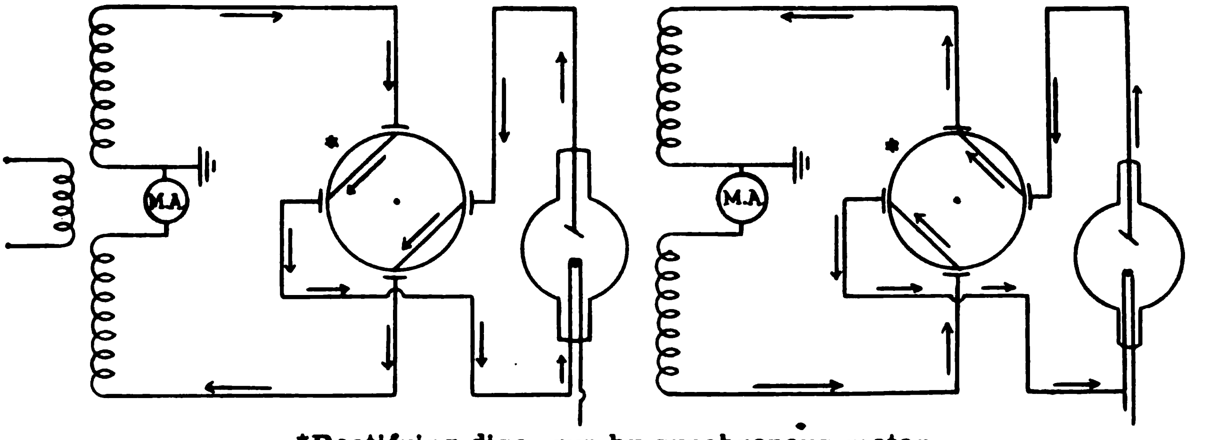
<u>Three phase systems:</u> In these, cycles are in effect tripled by having 3 sets of 60 cycle impulses follow each other at proper intervals. As a result the properly rectified high tension current so produced approaches constant potential.



TWO-VALVE TUBE RECTIFICATION
(Half Wave)

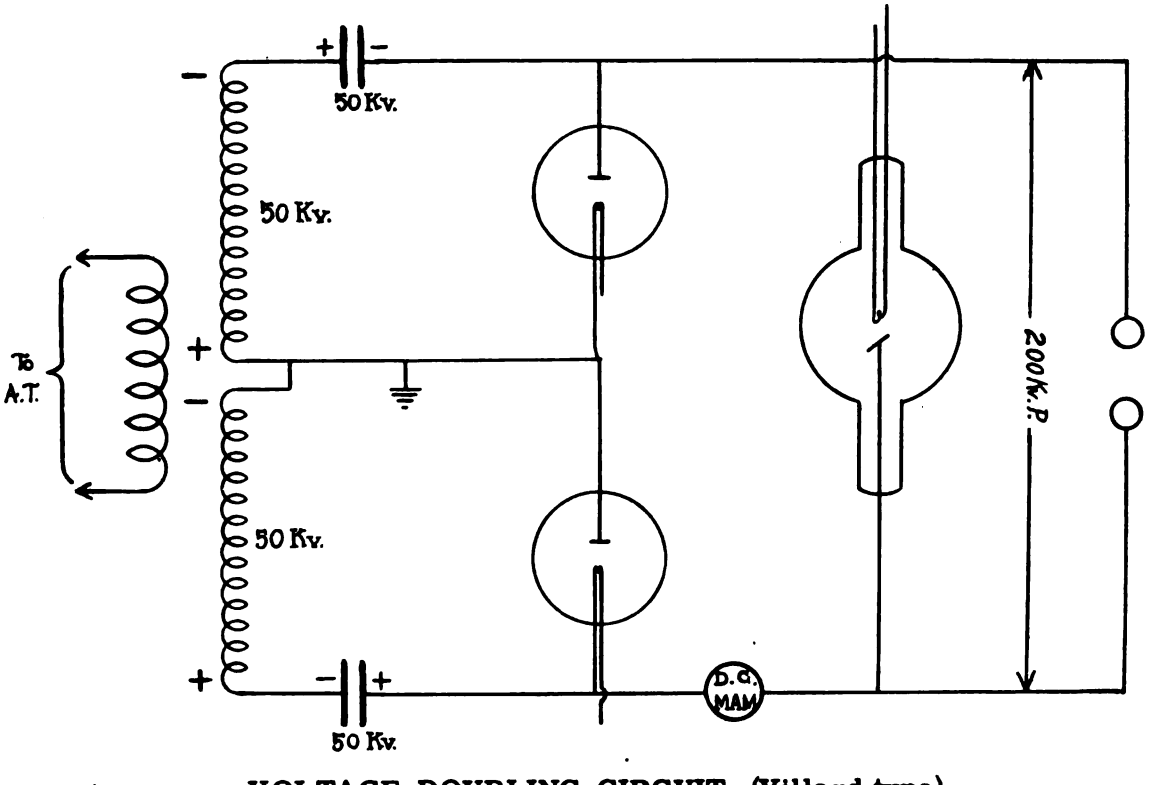


FOUR-VALVE-TUBE RECTIFICATION
(Full Wave)



*Rectifying disc, run by synchronous motor.

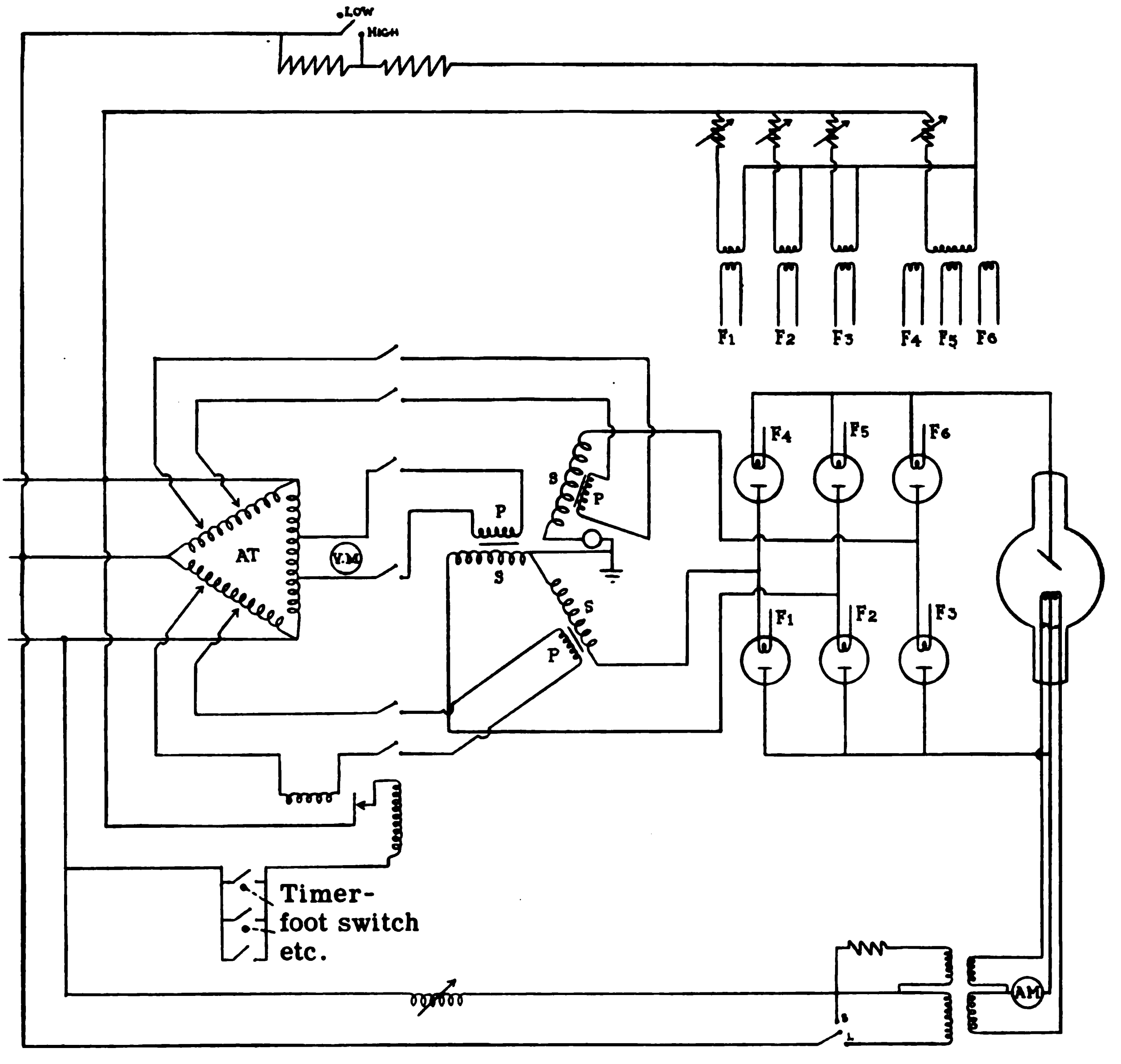
MECHANICAL RECTIFICATION
(Full Wave)

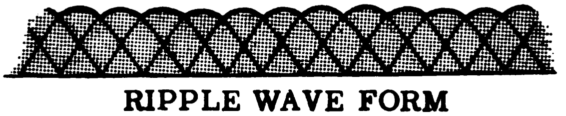


VOLTAGE-DOUBLING CIRCUIT, (Villard type).

The condensers charge on one impulse through the valve tubes and discharge on the next through the X-ray tube. It will be noted that the condenser and transformer voltages are in series on discharge, hence they add.

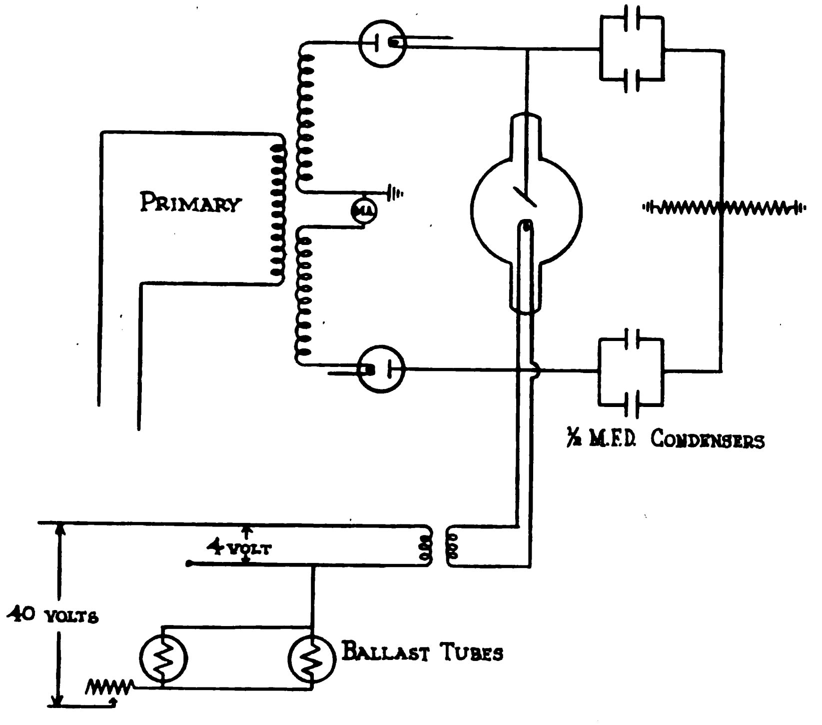
1. Page 22 - Illustration: Place "MA" on meter in secondary.




RIPPLE WAVE FORM

THREE-PHASE RECTIFICATION
(Full Wave)

<u>Condenser discharge system:</u> In this, the apparatus is operated in conjunction with a single phase transformer to charge a series of condensers to the desired kilovoltage. They may then be discharged through the X-ray tube. These machines have been very successful in chest radiography and are in use for photofluorography. They have an important advantage of being operable on low capacity line currents.



CONDENSER DISCHARGE

The condensers charge with filament heated at 4 volts, causing very low emission but after the condensers are charged the filament is heated to incandescence by 40 volts potential through the ballast tubes. The condensers then discharge through the X-ray tube.

X-RAY TUBES:

An X-ray tube consists of the following:

1. Glass bulb with a practically complete vacuum.
2. Cathode or negative terminal containing a tungsten filament.
3. Anode having a tungsten target.

Operation:

1. The cathode filament is heated and emits electrons in proportion to its degree of incandescence.
2. An E.M.F. of high K.V.P. is applied to the terminals which drives a stream of electrons into the tungsten target of the anode.
3. X-rays are thereby produced and radiate from the tungsten target.

The anode of most modern tubes consists of a solid block of copper in which a tungsten button has been placed. Tungsten is used because it is a good emitter of electrons and has a high melting point. In the older Coolidge tubes a solid tungsten anode was used.

The angle of the target is now about 15 to 20 degrees. In older tubes a 45 degree angle was used. In the rotating anode tube, the target revolves at high speed so that when heavy currents are brought to a small focal point the load will be well spread over a large ring shaped area.

The cathode contains a spiral of tungsten wire heated by four amperes or more of current at about 12 to 15 volts. The filament is contained in a molybdenum hood which terminates in a focusing cup. This serves to focus the electrons on a small area of the anode target. The smaller the focal spot of the electron stream the less the diffusion of radiographic images and accordingly the sharper the pictures. The focal areas are now linear as this permits of a smaller effective focal spot than the older oval type.

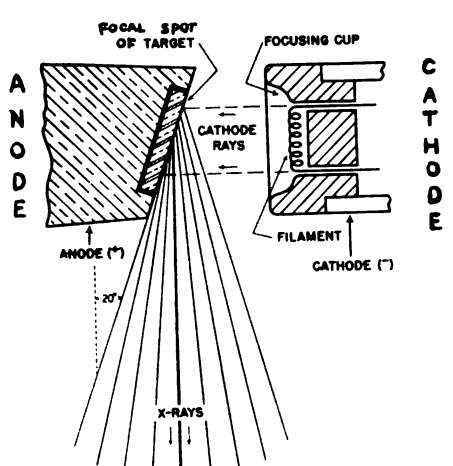


Diagram of line-focus tube depicting formation of x-rays.

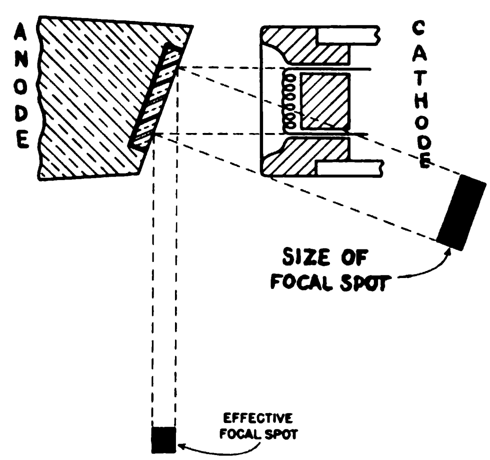
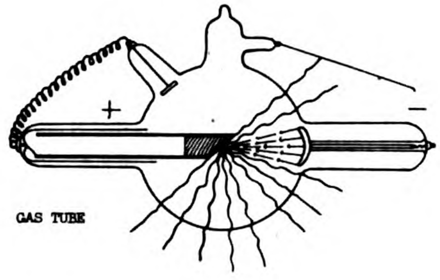
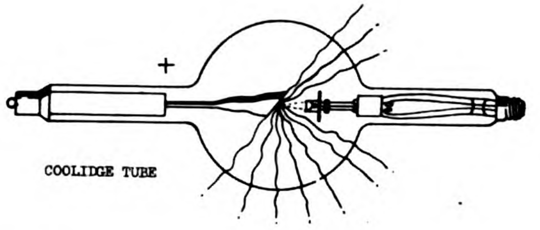


Diagram of line-focus tube depicting relation between actual focal spot (area of bombardment) and effective focal spot, as projected from a 20° anode.

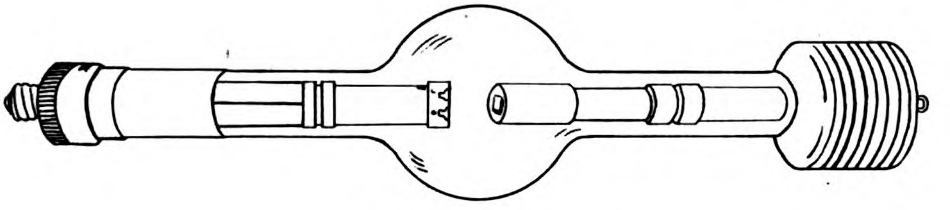
TYPES OF X-RAY TUBES



GAS TUBE



COOLIDGE TUBE



RADIATOR TYPE TUBE

ROTATING ANODE ASSEMBLY

CATHODE ANODE

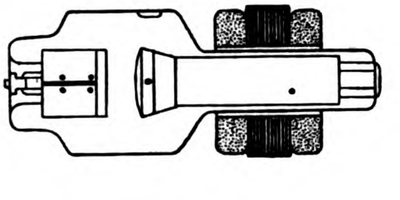
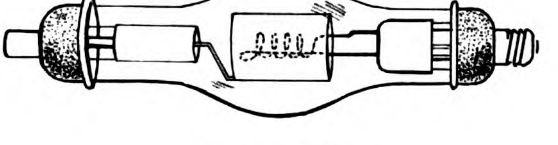


DIAGRAM OF ROTATING ANODE TUBE

FORCE DRAFT COOLED



VALVE TUBE

TUBE CAPACITY CHARTS

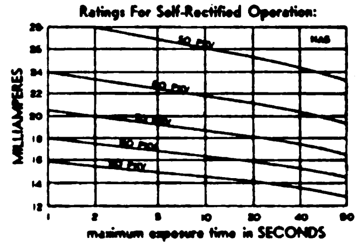
DENTAL UNIT

MA	KV	TIME(SECS.)
15	70	12
10	75	12
10	70	14
10	65	30
5	70	CONT. UP TO 60

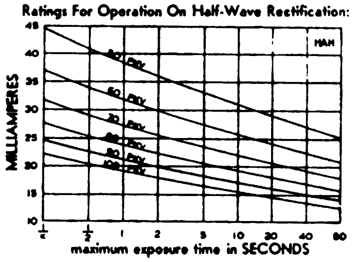
"A" FOCAL SPOT

Effective Size — 1.5 m.m.

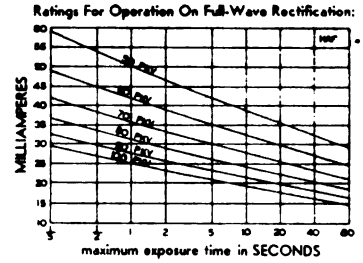
Ratings For Self-Rectified Operation:



Ratings For Operation On Half-Wave Rectification:



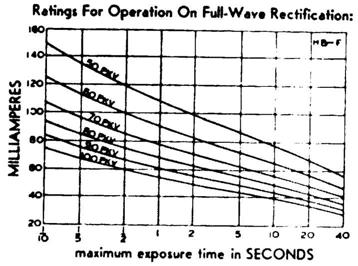
Ratings For Operation On Full-Wave Rectification:



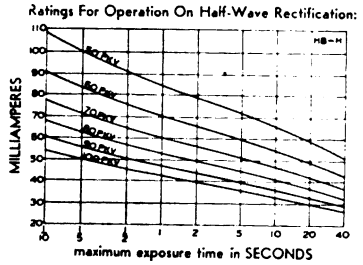
"B" FOCAL SPOT

Effective Size — 2.3 m.m.

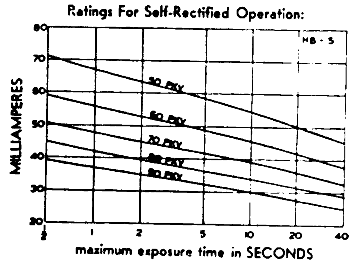
Ratings For Operation On Full-Wave Rectification:



Ratings For Operation On Half-Wave Rectification:



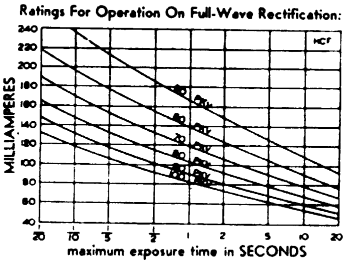
Ratings For Self-Rectified Operation:



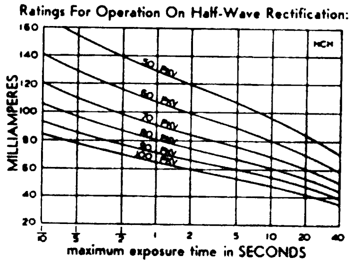
"C" FOCAL SPOT

Effective Size — 3.2 m.m.

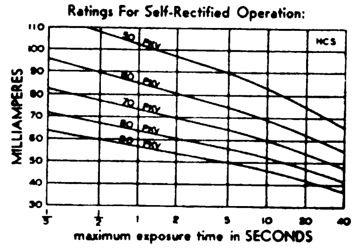
Ratings For Operation On Full-Wave Rectification:



Ratings For Operation On Half-Wave Rectification:

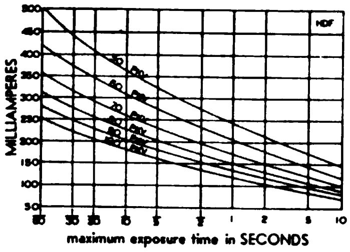


Ratings For Self-Rectified Operation:

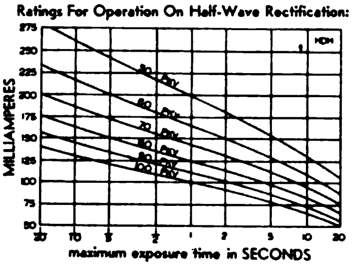


"D" FOCAL SPOT
Effective Size — 4.2 m.m.

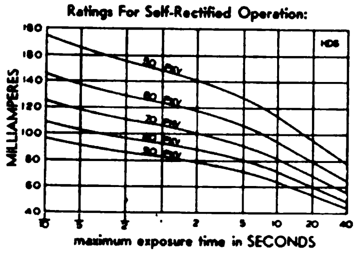
Ratings For Operation On Full-Wave Rectification:



Ratings For Operation On Half-Wave Rectification:



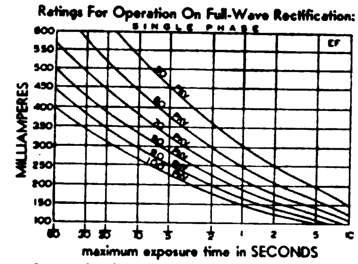
Ratings For Self-Rectified Operation:



"E" FOCAL SPOT
Effective Size — 5.0 m.m.

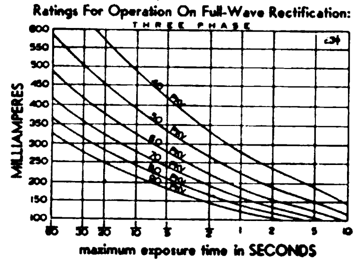
Ratings For Operation On Full-Wave Rectification:

SINGLE PHASE

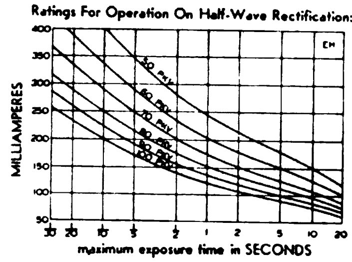


Ratings For Operation On Full-Wave Rectification:

THREE PHASE



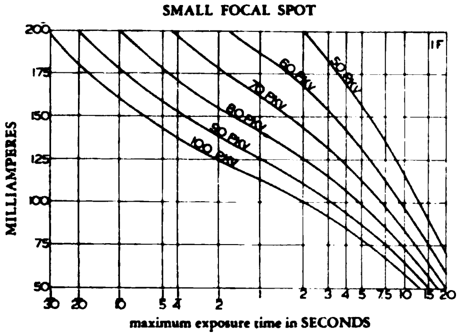
Ratings For Operation On Half-Wave Rectification:



FULL WAVE RECTIFICATION (SINGLE PHASE)

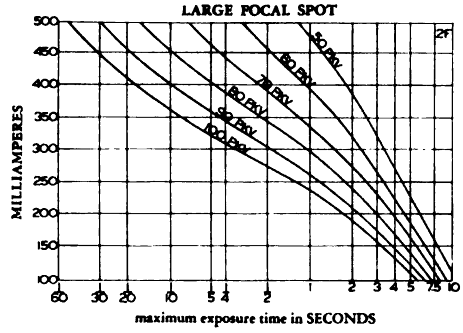
1 mm. FOCAL SPOT ROTATING ANODE

SMALL FOCAL SPOT



2 mm. FOCAL SPOT ROTATING ANODE

LARGE FOCAL SPOT

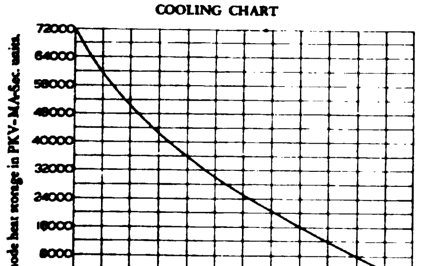


Fluoroscopic Rating: 85 PKV, 4 MA, 2½ min. in every 5.

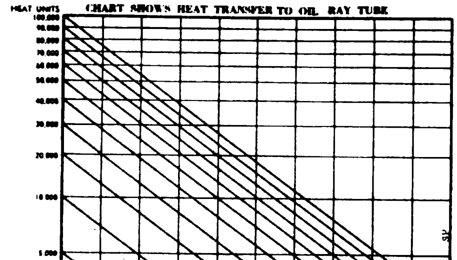
COOLING CHARTS - HEAT UNITS EQUAL K.V.P. x MA x TIME (SECS.)

COOLING CHART FOR ROTATING ANODE

COOLING CHART

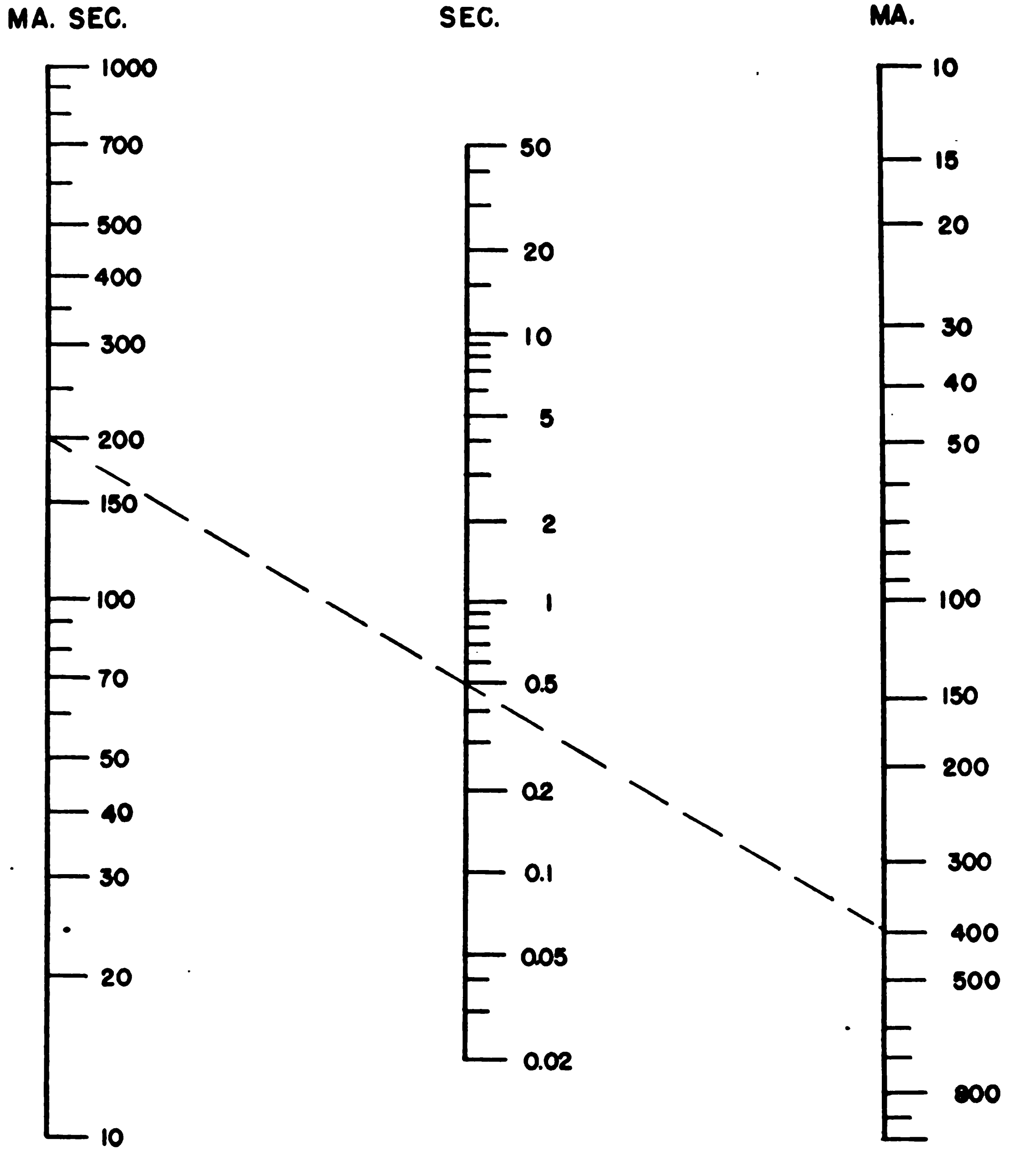


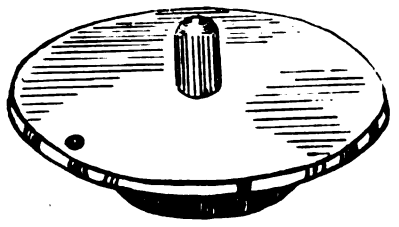
COOLING CHART FOR STATIONARY ANODE



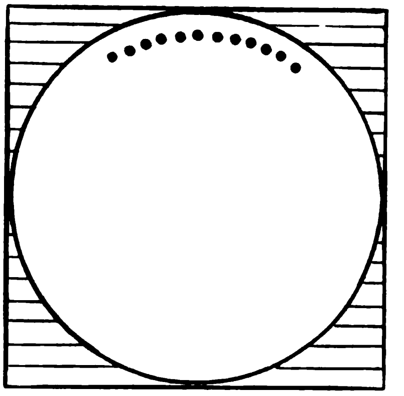
The nomogram below serves to resolve the mAsec. product in the factors exposure time (in sec.) and intensity of tube current (mA's). A straight line connecting two factors will give the required quantity by its intersection with the third factor.

Example as shown in the nomogram:
200 mAsec. are obtained with 400 mA's and 0.5 sec.

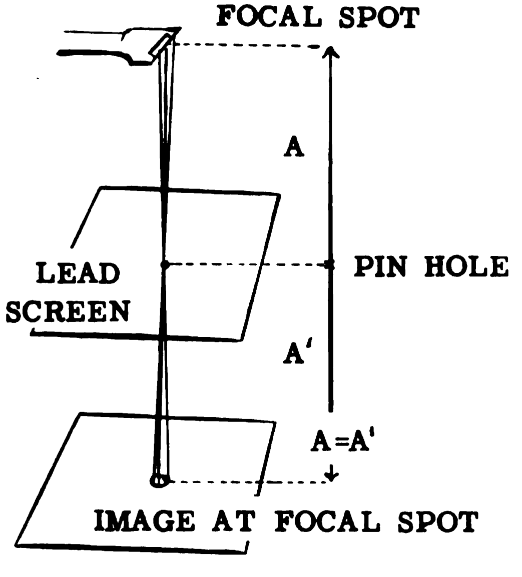




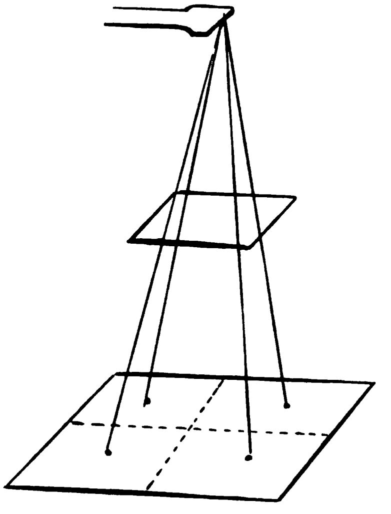
SPINNING TOP



Film showing spinning top test.
Each dot = 1/120 sec.
(60 cycle, full wave).



PIN HOLE CAMERA



INVERSE SQUARE LAW

A few pointers about tubes:

1. The smaller the focal spot the finer the definition.

2. Slight pitting of the target is of no particular consequence but marked cracking or melting indicate that heavy overloading has been inflicted on the tube. Such a tube has little life in prospect. In addition its effective radiation may be reduced as much as 25% or more.

3. Cooling of self rectified tubes is extremely important and overheating must be avoided.

4. When a tube becomes unduly luminous, i.e., shows more than the customary faint green fluorescence, it is probably more or less gassy. Gas arises from the walls of the tube and from the terminals due usually to overloading. Such tubes operate unsteadily and tend to transmit too much current. They are "cranky".

Improvement may be brought about by passing a current of 3 to 4 milliamperes at 70 to 80 K.V.P. through the tube for a half hour, repeating if necessary. However, not all tubes and circuits will permit this operation. Consult rating charts. However, if the tube shows an appreciable amount of blue or pink glow, it is past help.

5. Dust and moisture tend to accumulate on exposed types of X-ray and valve tubes due to electrical effects. This may lead to spark over and puncture. Thus frequent cleaning of such tubes is needful.

6. The purple discoloration of glass is due to X-ray and is of no consequence. Any mirror effect of metallic type, however, is due to tungsten and usually signifies overloading of the tube. Diminished output of X-ray is caused by this and the tube is more liable to puncture.

7. If X-ray tubes are not used beyond their rated capacity their life will be greatly extended. If they are used consistently at 20% lower than maximum rating, the tube life will ordinarily be tripled. The capacity of the tube depends largely on its ability to dissipate heat. It is good practice to keep capacity charts posted in a conspicuous place.

The filaments of many tubes, especially rotating anode tubes appear quite vulnerable to overloading. Accordingly the 20% rule is important on this score also.

This makes it of prime importance to avoid keeping the filament lit for long periods when it is on high capacity settings.

8. Filament characteristics of the vacuum tube differ and when tubes are changed, adjustments will often be needed even though the tubes are of similar type and capacity.

9. Direct radiation from a tube is that which comes from the focal spot. Stray radiation comes from other parts of the tube. It can be demonstrated by a

pin-hole camera. Secondary radiation is produced in objects as X-rays pass through them.

10. "Soft" radiation is of long wave length and is produced by low voltages. It is less penetrating. "Hard" radiation is of shorter wave length, is produced by the high voltages, and is more penetrating.

11. Spare tubes should be put into operation occasionally. This is particularly important in the case of rayproof tubes in a damp climate.

12. When temperature changes are involved in the replacement of a tube (removal from a storeroom of low temperature) allow the tube to remain in the X-ray room for some hours (preferably twenty-four) before use.

QUESTIONS:

1. Who discovered the X-ray?
2. To what physical property is the penetrating power of X-ray due?
3. What is the length of an Angstrom unit?
4. Differentiate between the conventional theory of flow of electricity and present belief.
5. What do we mean by potential?
6. Are all electrons alike? What is their source?
7. Name 5 good conductors; 5 insulators.
8. What is Ohm's law?
9. What is the unit for condenser capacity?
10. Describe three ways of generating electric current.
11. What types of current are used to activate induction coils and transformers? Why? What is meant by impedance?
12. What is the purpose of the autotransformer?
13. Differentiate between cathode rays and X-rays.
14. Explain the operation of an X-ray tube on unrectified current.
15. Draw a 4-valve rectified transformer unit including the X-ray tube.
16. What is the main advantage of the 3 phase system?
17. What is the difference between condenser discharge and conventional X-ray machines?
18. Describe the operation of an X-ray tube.
19. What effect does the size of the focal spot have on the image?
20. What would lead you to suspect a hot cathode X-ray tube of being "gassy"?
21. Differentiate between stray and secondary radiation.
22. How is the penetrating effect of X-rays controlled?

FILM, SCREEN, AND DARK ROOM PROCEDURES.

From the standpoint of practical roentgenology, one of the most important properties of X-ray is the ability to affect photographic emulsions and make possible the production of X-ray pictures.

Photographic emulsions consist of gelatin containing various mixtures of silver halides notably silver bromide and iodide. Such emulsions are affected by actinic rays including ordinary light, infra red (special type emulsion), ultra violet, X-ray and the gamma rays of radium, these last rays being shorter and still more penetrating than X-rays but otherwise similar. The effect of actinic rays on the silver halides is to disarrange their electron patterns, and, if the rays are applied sufficiently long, to cause these compounds to disintegrate with the formation of metallic silver in finely divided state. The emulsion blackens as the result. However, long before such occurs there is merely a change in the electron pattern which is undetectable by the closest physical examination but which none the less affects the silver halides so that they are extremely susceptible to reducing agents in proportion to the amount of actinic rays that have reached them. Thus if we plunge an emulsion coated film or glass plate, part of which has been exposed to X-ray or light, into a solution of a reducing agent, this part of the emulsion will show reduction of the silver halide to metallic silver and consequently appear black. The unexposed portion will be unchanged.

Photographic emulsions are of many types and their production is an intricate specialty. There are both fast and slow emulsions, and emulsions sensitized to various shades of light. The slower emulsions have a preponderance of small particles and so are "fine grain". The very fast emulsions are coarse grain. Regular X-ray emulsions are specialized along the lines of speed, contrast and sensitivity to the light of intensifying screens. A special emulsion is designed for direct X-ray only and is used for "non-screen" film.

Emulsions are now coated on a flexible base of cellulose acetate, usually tinted a pale blue. This base is less inflammable than ordinary paper and so is quite safe as regards fire hazards. Formerly nitro-cellulose was used. This was highly inflammable and moreover when burned gave off highly poisonous fumes. In the earliest days glass plates were used. Needless to say these were heavy, fragile and generally difficult to work with. The coating of X-ray emulsion is usually about .001 inch thick and is applied to both sides of the film.

Since films are very sensitive it is necessary to use care in handling and storage. Further,since films are affected by X-ray and since X-rays are exceedingly penetrating, films must be stored at a safe distance from X-ray or protected by lead. Heat and moisture have very adverse effects and so films should be kept in cool dry places and never placed near or upon radiators or steam lines. Many chemicals such as formalin vapor, hydrogen sulphide, ammonia, hydrogen peroxide, illuminating gas, etc., injure films and thus films should not be stored in drug rooms or near chemical laboratories. Rough or careless handling will result in such things as creases, crimp marks, buckling, tears, scratches, static electricity marks, dirt streaks, solution streaks, finger marks, fogging and various other damage.

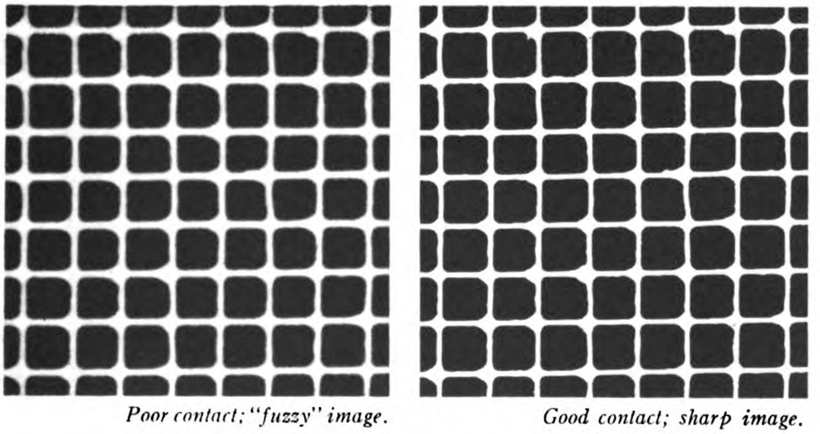
The purpose of using film is of course to obtain an X-ray picture or radiograph. By reason of the penetrating power of X-rays and the impossibility of focusing them, it is obvious that we will obtain something altogether different from a photograph. What we obtain is a shadow picture built up of various densities and in which, of course, the bony structures will stand out with the greatest distinctness as relatively translucent areas, because of their greater density.

Screens: Another property of X-ray is used in order to augment effect on films. This property is the one of causing certain substances,notably various tungstates and also zinc sulphide,to fluoresce.

It is thus apparent that, if we place a cardboard coated with fluorescent chemicals next to the film, the fluorescent light produced when X-ray is applied will reinforce the direct action of the X-ray. In practice a thin screen is used above the film and a thicker beneath so that the effects are doubled. These screens are fastened in hinged containers of suitable size called cassettes and their use is spoken of as double screen technique. Screens are supplied in varying speeds, the slower being fine grain and the faster coarse grain. Slow speed screens are thus used for finest definition, mid or par-speed screens for general utility, and super-speed screens when the utmost speed is desired as in chest work. In general, mid or par-speed screens will answer nearly all purposes well enough.

The cassettes are substantially made and stand up well under strenous use. However, in time damage and deterioration occur. The main types of trouble are as follows:

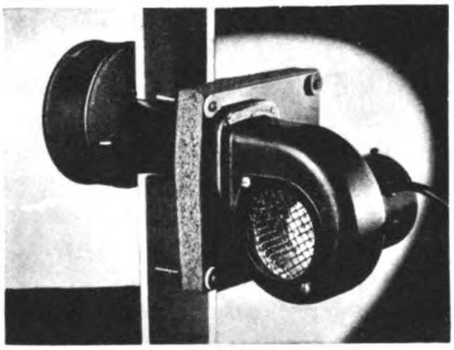
1. Warped or dented fronts. This is apt to cause areas of poor contact between screens and films with resultant blurring of detail. To test for this, make an exposure of galvanized wire mesh. Areas of poor contact will readily be detected by fuzzy outlines of the wire. Such cassettes usually need replacement. However, careful padding out of the screen may remedy the trouble at least temporarily.



Poor contact; "fuzzy" image. *Good contact; sharp image.*

2. Worn felts. These may cause light leakage.

3. Cracked frames, broken hinges, etc. Obviously the cassette is apt to disintegrate or permit light leakage and poor contact. Replacement is in order.

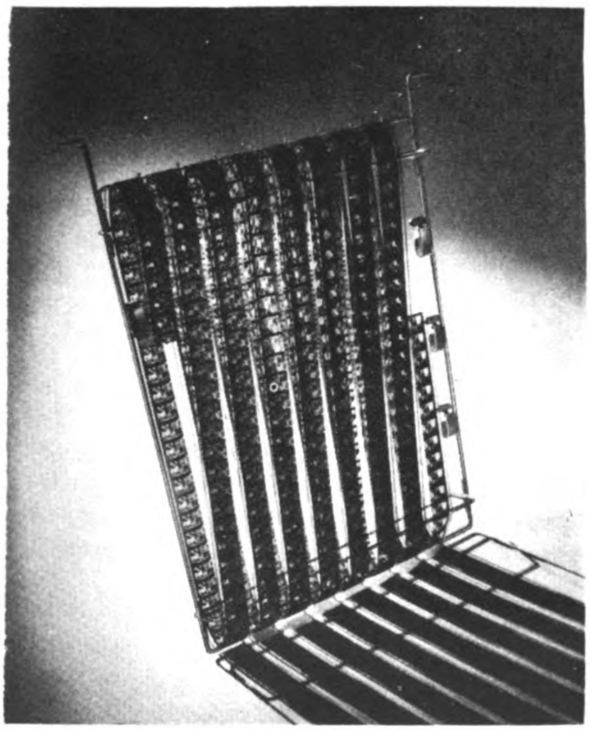


DARKROOM VENTILATOR

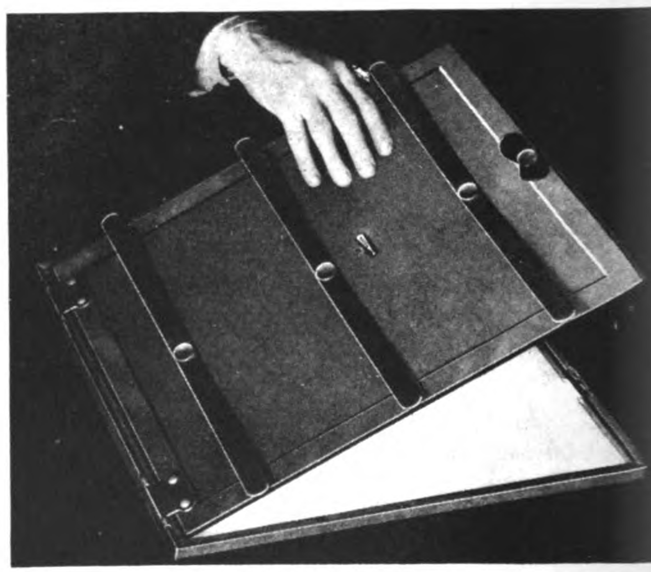
When placing film in developing hanger, first attach two bottom clips.

Then attach the two spring clips at the top of the hanger.

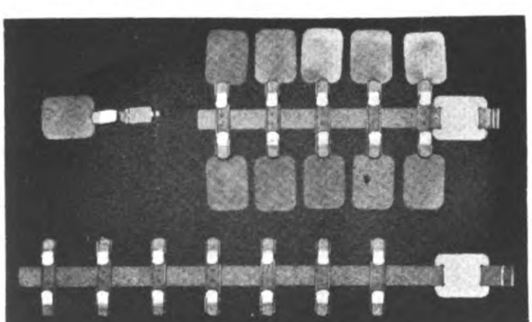
MOUNTING FILM IN HANGER



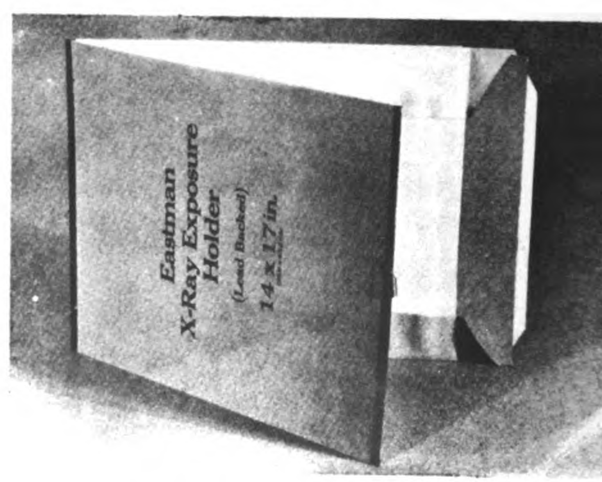
HANGER FOR 35 mm. FILM



CASSETTE



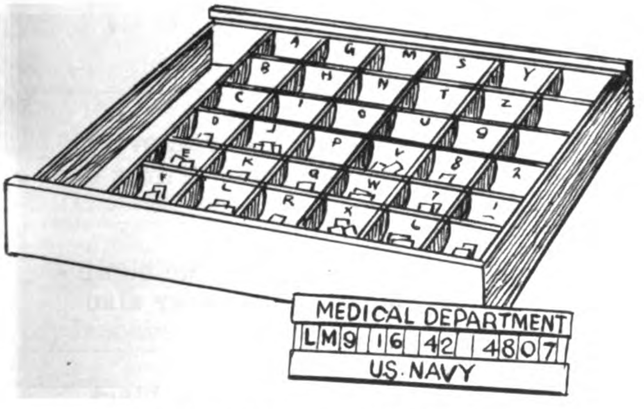
DEVELOPING HANGERS
FOR DENTAL FILM



PLAIN FILM HOLDER

RADIOGRAPHIC AND DARKROOM EQUIPMENT

DARKROOM PROCESSING TANKS



FILM MARKING SET

FILM STORAGE BIN

4. Scars and stains on the screens. These will inevitably mar the radiograph by producing spots. Processing chemicals are especially ruinous to screens. Ordinary soiling can be taken care of by washing with a neutral soap such as castile, "Ivory" or "Swan", etc. A pledget of cotton moistened with suds is used promptly followed by sponging with pledgets wet with water. Never use alcohol, acetone, ether carbon tetrachloride, etc., unless the screen manufacturer explicitly recommends such. (Some makers suggest use of pure grain alcohol for their screens, applied gently by means of cotton pledgets).

Damaged screens of course need replacing.

5. Radiopaque substances on cassette. Simple inspection should usually detect these. However, when necessary such may be tested for by an exposure of the cassette containing a film still in its black paper. Any defects on the film will thus not be due to faulty screens.

6. Lint, dust, bits of paper, etc. on the screens. These produce white spots on the film. Periodic use of a camels hair brush will cure or prevent this.

General Precautions:

1. Avoid rough handling.

2. Do not leave cassettes open.

3. Be sure hands are dry and free of processing chemicals before touching cassettes.

4. Do not mix processing solutions on the loading benches.

5. Do not dig at films with the fingernails, pens, pencils, etc., to remove them from the cassettes. This will soon damage or loosen the screens. Films can be tilted out, if a convenient corner fails to be caught by a finger tip.

6. Be sure screens are well secured in the cassettes. Otherwise the humiliating and expensive accident of developing a screen may happen. They may also fall on the deck and be damaged.

7. When loading the cassette it is of course necessary to remove the black paper. This should be done gently, preferably by letting the bottom layer fall away from the film whereupon the film can be placed in the cassette and the upper layer lifted off. In this way there is less chance of particles of paper lodging in the cassette.

PROCESSING SOLUTIONS:

(a) Developer:

The term "developer" has resulted from the fact that this solution produces or developes the photographic image on the film, plate or paper. Chemically, however, the essential reagents of developer are reducing agents in that they produce reduction of silver halides to metallic silver.

There are an exceedingly large number of chemical agents that are used for this purpose but in most X-ray work we have only to do with a few, namely, elon or metol and hydroquinone. Elon and metol are less active but bring out detail. Hydroquinone is the more active and intense. It produces density and contrast, but loses activity rapidly as the temperature drops to 60° F. or lower and so a developing temperature below 60° F. cannot be used with good results. At high temperature activity is too intense and once more good results become impossible. The optimal range is 63° F. to 68° F. This is not to say that work may not be done at other temperatures but to indicate that the results will fall notably short of high standards whenever the 63-68° F. range is grossly deviated from.

To prevent rapid oxidation of the reducing or developing agents sodium sulphite is made use of. Proper developement also requires the presence of an alkaline reaction and the alkali carbonates (usually sodium) are used for this purpose. A restraining agent is necessary to prevent overaction and to keep the "whites" clear. Potassium bromide accomplishes this. It might be noted here that if excessively high developing temperatures are unavoidable the bad effects will be lessened by increasing the amount of bromide.

Developer may be prepared by weighing out the chemicals and dissolving them in accordance with formula, but as this is seldom convenient in most laboratories it is the usual practice to use ready mixed developers prepared by the film manufacturers. These may be requisitioned from the Naval Supply Depots.

DEVELOPING FORMULA

FOR....	1 QT.	1 GAL.	5 GAL.	10 GAL.
Water	1 Pt.	2 Qts.	2-1/2 Gal.	5 Gal.
Elon or Metol	30 Gr.	1/4 Oz.	1-1/4 Oz.	2-1/2 Oz.
Sod. Sulphite, anhydrous	3 Oz.	12 Oz.	4 lb.	8 lb.
Hydroquinone	150 Gr.	1-1/4 Oz.	6 -1/4 Oz.	12-1/2 Oz.
Sod. Carbonate, anhydrous	1 Oz.	4 Oz.	1-1/4 lb.	2-1/2 lb.
Pot. Bromide	90 Gr.	3/4 Oz.	4 Oz.	8 Oz.
Cold Water to make Total	1 Qt.	1 Gal.	5 Gal.	10 Gal.

DEVELOPING FORMULA (METRIC)

FOR......................	1 Liter	4 Liters	20 Liters	40 Liters
Water	500 cc.	2,000 cc.	10,000 cc.	20,000 cc.
Elon or Metol	2 grams	8 grams	40 grams	80 grams
Sod. Sulphite Anhydrous	75 "	300 "	1,500 "	3,000 "
Hydroquinone	10 "	40 "	200 "	400 "
Sod. Carbonate Anhydrous	30 "	120 "	600 "	1,200 "
Pot. Bromide	6 "	24 "	120 "	240 "
Cold Water to make Total	1 Liter	4 Liters	20 Liters	40 Liters

Dissolve in order. Time 5 Min. at 65 degrees F.

The developing time of 5 minutes is the same as for many commercial developers. This time must be varied for different temperatures and a time temperature chart should be posted in every dark room.

Many developers now have a processing time of 3-1/2 minutes and will naturally require a different set of figures.

TIME-TEMPERATURE DEVELOPING CHART

	Standard developer		Rapid developer	
Temperature	Regular film	Non-screen film	Regular film	Non-screen film
60° F.	6-1/2 min.	11 min.	5 min.	8-3/4 min.
63 "	5-3/4 "	10 "	4-1/4 min.	7-1/4 "
65 "	5 "	8 "	3-1/2 "	6 "
68 "	4-1/4 "	6 "	3 "	5-1/4 "
70 "	3-3/4 "	4-1/2 min.	2-1/2 "	4-1/2 "
73 "	3-1/4 "	3-3/4 "	2-1/4 "	4 "
75 "	3 "	3-1/2 "	2 "	3-1/2 "

~~Developer naturally loses strength with use and age and it should be well covered to limit oxidation. When 5 gallons of solution has been used to develop about~~

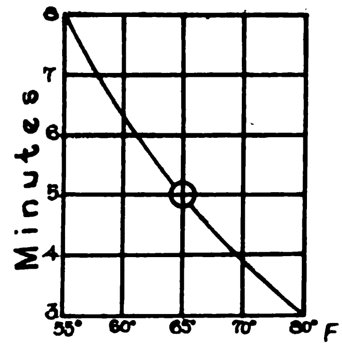


CHART
5 MINUTE DEVELOPER

Developer naturally loses strength with use and age and it should be well covered to limit oxidation. When 5 gallons of solution has been used to develop about 100 - 14 x 17 films or the equivalent,developing time should be increased by a minute. After 50 more films have been developed another minute should be added and the solution replaced promptly.

In most laboratories it will be found convenient and practical to replace developer weekly.(See appendix).

Regardless of volume of work, developer kept in a processing tank should be replaced every few weeks. If the amount of work is exceedingly small it may be worth while to store the developer in jugs, filled to the neck and tightly stoppered. Here it will keep indefinitely, especially in cool dark surroundings.

Fresh solution is added to prevent the level in the tank from falling. Never add more chemicals to strengthen or "spike" the solution.

ONE MINUTE DEVELOPER

Occasionally it is necessary to process films with the utmost speed. As an aid in this a one minute developer can be used. This is made up as follows:

Stock solution:	Water.	96 oz.
	Sod. Sulphite, dessicated . . .	12 oz.
	Hydroquinone	6 oz.
	Sod. Hydroxide (caustic soda). .	5 oz.
	Potassium Bromide	4 oz.
	Water to make	1 gallon.

Dissolve the chemicals in the order given.

Two parts of stock solution are mixed with one part of water and the X-ray

film is developed for about 60 seconds at 68 degrees F. The tray method is advisable so as to lessen amount of solution needed, because due to its poor keeping quality it must be discarded after use. The stock solution may be retained about two months without deterioration if kept in a well-stoppered brown bottle. Use film clips to keep the hands out of the solution. The solution depth should be about 3/4 inch and the film is immersed by a quick, sliding motion. If the film is not covered evenly, dark streaks in the radiograph will result. The film should be moved about frequently, while developing. Rinsing should be thorough before placing in the fixer. Fixation should be as usual but the film may be viewed after one minute.

DEVELOPER EXHAUSTION

Developing solution is added from time to time to maintain proper level. This compensates for exhaustion to some extent but not completely, so the developing time is lengthened as indicated in the following table.

Developer Exhaustion Table

Developing time 65° F.			Number of 14 x 17 films			
Standard Developer	Percentage of Normal	Rapid Developer	5 gallons	10 gallons	15 gallons	20 gallons
5:00	100	3:00	40	80	120	160
5:30	110	3:18	40	80	120	160
6:00	120	3:36	25	50	75	100
6:30	130	3:54	25	50	75	100
7:00	140	4:12	15	30	45	60
7:30	150	4:30	15	30	45	60

When the developing time has increased 50%, the developer should be discarded. A tally of films processed at the end of each days work will usually be found more practical than the dark room check-off at time of processing.

3 - 8 x 10 = 1 - 14 x 17 or 2 - 10 x 12 = 1 - 14 x 17
1 - 11 x 14 and 1 - 8 x 10 = 1 - 14 x 17

DEVELOPING IN WARM SOLUTIONS

When use of very warm solutions (not beyond 95 degrees F.) is unavoidable, the addition of 13 oz. of sod. sulphate to each gallon of developer will protect the emulsion. A special fixing bath will also be needed (q.v.).

For temperatures between 75 and 85 degrees F., the addition of 3 oz. Potassium Bromide to each 5 gallon regular developer will aid considerably in obtaining clear negatives.

Develope as follows:

Temperature	Time
70 degrees F.	4-1/2 min.
73 " "	4 "
75 " "	3-1/2 "
78 " "	3 "
80 " "	2-1/2 "
85 " "	2 "

(b) Short-Stop. When development is complete it is necessary to stop further action of the developer. Although ordinary rinsing answers well it is an advantage to use a short stop. Usually it consists simply of dilute acid and acts by neutralizing the alkaline developer clinging to the film. One half pint of glacial acetic acid or 1/2 pound of citric acid added to 5 gallons of water will answer. It should be tested with litmus or other indicator paper at intervals to determine when replacement is needed.

(c) Fixing Bath. The essential ingredient of the solution is sodium thiosulphate or "Hypo". This dissolves all unreduced silver halide and so clears the film. The metallic silver which forms the image is unaffected. In addition to hypo the fixing bath contains acid and alum to harden the gelatin emulsion, and promptly neutralize any alkaline developer that might still adhere to the film. Sodium sulphite is again used, this time to prevent breaking up of the thiosulphate by acid with resultant precipitation of sulphur.

POTASSIUM ALUM FIXING BATH

	English	Metric
Sodium Thiosulphate (Hypo)	25 lbs.	10 kilos
Water (120 degrees F.) to make	5 gallons	20 liters
Sodium Sulphite	1-1/4 lbs.	500 gms.
Glacial Acetic Acid	1-1/4 pts.	500 cc.
Potassium Alum	1-1/4 lbs.	500 gms.
Cold Water (70 degrees F.) to make	10 gallons	40 liters

Directions:

1. After thoroughly cleaning tank, place hypo crystals in it and add the warm water with stirring until completely dissolved.

2. Completely dissolve the Sodium Sulphite in 3 quarts of water and add to hypo solution with constant stirring.

3. Dilute the glacial acetic acid in 3 quarts of cool water and add to the tank slowly while stirring constantly.

4. Dissolve the potassium alum in 2 quarts of warm water, then dilute with cold water to make a gallon and add to tank slowly with constant stirring.

5. Bring tank up to 10 gallon level with cold water.

Never use water hotter than 120 degrees F. Be sure solution has cooled before adding acid. (There should be little difficulty as hypo chills the solution as it dissolves).

Note: 1-1/4 lbs. (or 500 gms.) citric acid may be substituted for the glacial acetic acid in the above formula. Be sure it is completely dissolved before adding to the hypo solution.

A chrome alum fixer bath is often preferred. It has a greater hardening action when fresh but loses its hardening effect more rapidly than the other types.

CHROME ALUM FIXER

FOR	1 GAL.	5 GAL.	10 GAL.	20 GAL.
Sod. Thiosulphate	2-1/2 lb.	12-1/2 lb.	25 lb.	50 lb.
Sod. Sulphite	3 oz.	1 lb.	2 lb.	4 lb.
Water	2-1/2 Qt.	3 Gal.	7 Gal.	14 Gal.

Dissolve completely and prepare following solution separately:

Chrome Alum	3 oz.	1 lb.	2 lb.	4 lb.
Water	1 Qt.	1-1/2 Gal.	2 Gal.	4 Gal.
Sulphuric Acid (CP)	1/4 oz.	1-1/4 oz.	2-1/2 oz.	5 oz.

Add sulphuric acid slowly and with stirring. When both solutions are cool and completely dissolved add the alum acid mixture slowly to the hypo-sulphite, stirring vigorously. Make up to full amount with water.

CHROME ALUM FIXER (METRIC)

For	4 Liters	20 Liters	40 Liters	80 Liters
Sod. Thiosulphate	1000 grams	5000 grams	10,000 grams	20,000 gm.
Sod. Sulphite	100 grams	300 grams	1000 grams	2000 gm.
Water	3 Liters	15 Liters	28 Liters	56 Liters

Dissolve completely and prepare following solution separately:

Chrome Alum	100 grams	500 grams	1000 grams	2000 gm.
Water	750 cc.	3 Liters	6 Liters	12 Liters
Sulphuric Acid (CP)	7 cc.	37 cc.	75 cc.	150 cc.

Commercial preparations are also available for preparation of fixing bath and may be obtained from the Supply Depot in various sizes.

One Concern is now furnishing a rapid action fixing bath which is stated to clear the film in one minute and "fix" in three.

Developing and fixing baths are commercially available in both dry and liquid forms.

For fixing films when solutions are excessively hot the following is recommended:

HOT SOLUTION FIXER

Hypo.	2 lbs.
Anhyd. Sod. Sulphite	6 oz.
Water	2 qts.
Formalin (ordinary commercial 40%). .	1 pt.
Water to make	1 gal.

Since this solution is not acid, an acid short stop is imperative. Use clips and keep hands out of the solution.

Fixing bath gradually loses strength and becomes exhausted. When the time needed to clear a film has doubled (6-8 min. instead of less than 5) the solution should be replaced.

The usual time for clearing and proper hardening is 15-20 min. Films should not be exposed to strong light before they are cleared or fogging will result.

With the foregoing in mind it is easy to understand the details of processing. These are as follows:

(a) Development:

The films are taken from the cassettes, or other holders, and mounted in hangers, each corner being well secured so that there is no bulging of the film. The hanger and film are then immersed in the developer tank for the prescribed period in accordance with the time, temperature, and exhaustion tables. During this period the film is moved up and down occasionally to insure even developing and cause detachment of any air bubbles. Inspection of the films during development should be avoided especially in the first few minutes. On rare occasions inspection may be necessary but such practice easily grows into an insidious and harmful habit. It occasions more or less fog, increased oxidation of the solution and prevents proper evaluation of exposure technique. Further it does not accomplish good results in the way of correcting over or under exposure. Sight development should only be used to prevent complete ruin of important films or for some special purpose.

(b) Rinsing or Short Stop:

When development is over the films are lifted from the developer promptly, held over the developing tank to drain for about 5 seconds and then dipped in the short-stop or rinse water for 15 seconds. More than 5 seconds for draining films is not recommended as developer spread over film surfaces oxidizes rapidly. If a short stop is used do not use rinse water in addition.

(c) Fixation:

The films are next placed in the fixing bath where they remain for 15 minutes. Do not hold films up to a strong light until clearing is complete. However, it is not necessary to limit illumination to the safelight after the film has been in the fixer for a minute.

(d) Washing:

This is carried out for 30 minutes in running water at a temperature of less than 70 degrees F. Some tanks have two washing compartments, a small one and a large one. The small is next to the fixing tank and receives the bulk of contaminating solution. The larger is next in line and gets but little contamination. In this way when large numbers of film are processed, washing will still be adequate without increasing time.

When solution temperatures are high it may be necessary to greatly curtail washing even at the sacrifice of keeping quality. After all such a film is better than one with a melted emulsion.

There are very apt to be occasions in the Naval Service when fresh water is at a premium. It is well to remember then that clean sea water will accomplish rapid removal of "Hypo" from photographic films and paper. Thus the washing operation can be accomplished as follows:

1. Sea Water - - - - - - - - 15 to 20 minutes followed by - -
2. Fresh Water- - - - - - - 5 minutes.

Running water should be used in each instance if possible; otherwise employ 4 to 6 changes.

(e) Drying:

This is best done in special dryers made for the purpose. The dryers should be loaded from back to front to prevent dripping of water on films with resultant streak formation. Dryers may of course be dispensed with if work is light, and the film placed to dry in any convenient place avoiding, of course, dust, direct sunlight, places where traffic is heavy, or, finally, where there is excessive dampness, poor air circulation or abundant chemical fumes. An ordinary electric fan will help a lot. Be sure films are not too close to each other. They stick readily when they are partially dried.

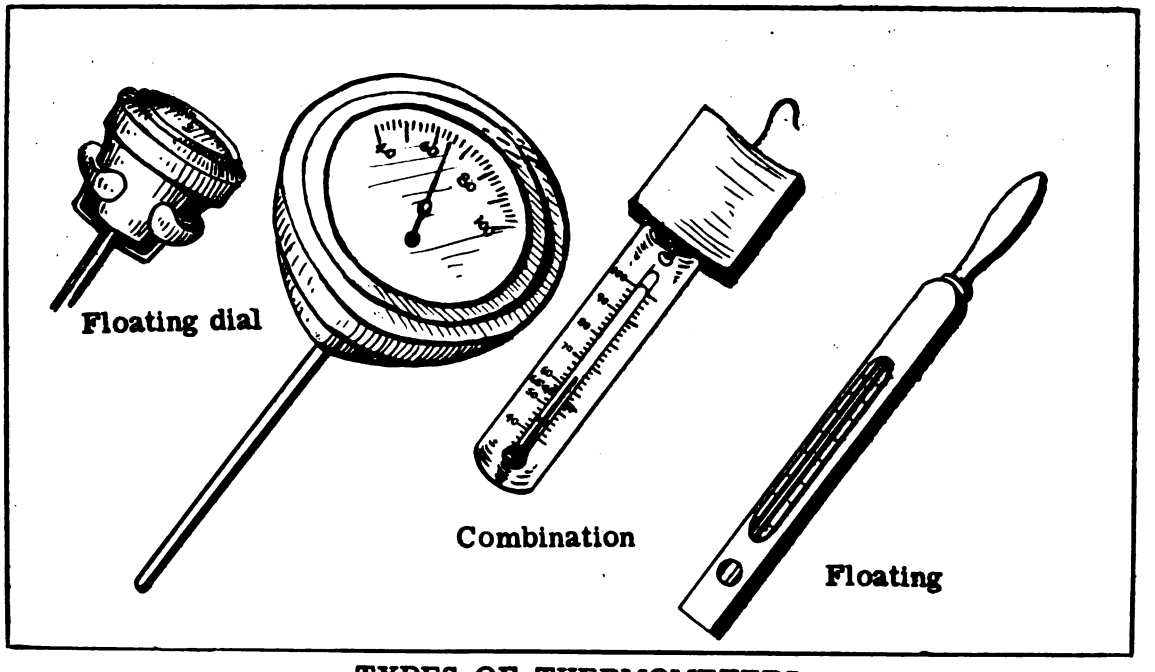
DARK ROOM EQUIPMENT.

The dark room is an important work room deserving of the best consideration. It is all too common to find some undersized "hole in the wall" or dingy closet set aside for processing. Ventilation, storage space, work benches, processing tanks, hot and cold water, etc. must all be provided for.

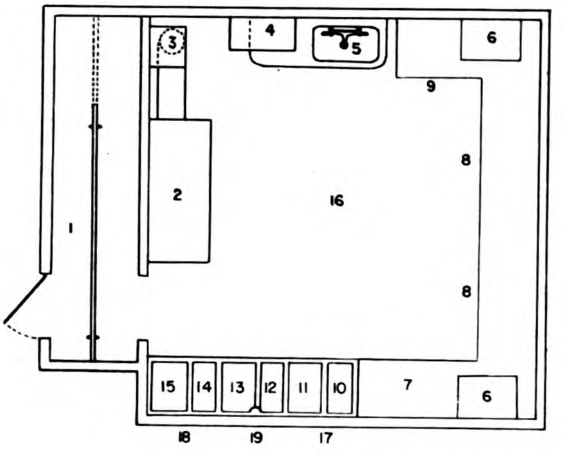
The dark room furthermore should be maintained in a state of strict cleanliness. Cleanliness is, of course, imperative on general principles and is a firm naval tradition. The sensitivity of films and screens to dust, dirt, and chemicals gives added force to this. When solutions are spilled, mop them up thoroughly and at once. Do not leave processing tanks in a bespattered condition. When a wet film must be carried from the dark room use some waste material to soak up drippings. When mixing chemicals, avoid careless handling that sends clouds of chemical dust into the air.

Hangers: The clips of the hangers should be sharp pointed and free of film debris so as to hold the film tightly. They should not project beyond the hanger, so as to scratch other films. Films should not be roughly jerked out of the hangers leaving particles of the film in the clip. Supports for various sized hangers should be mounted above the work bench.

Safelights: Use a standard filter recommended by film manufacturers and illumination bulbs of correct brightness (usually 15 watts).

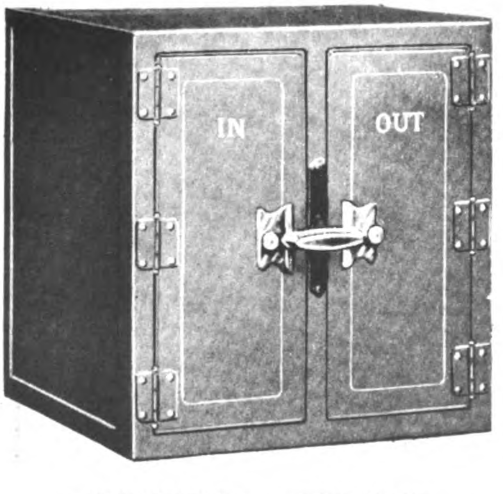


TYPES OF THERMOMETERS

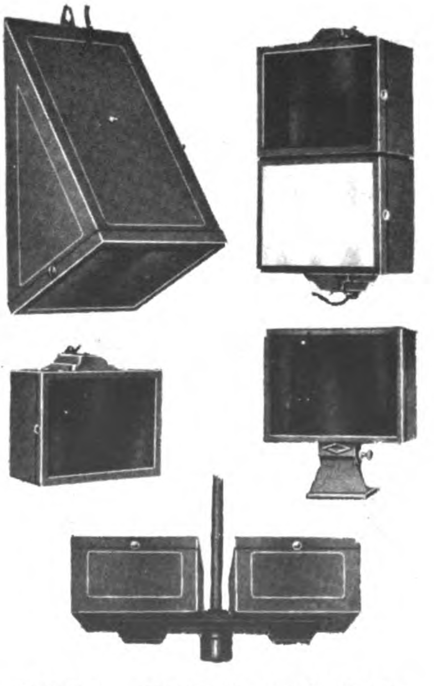


CONVENTIONAL TYPE OF DARKROOM

1. LABYRINTH
2. DRYER (24 film capacity)
3. EXHAUST DUCT
4. STORAGE CABINET
5. SINK
6. TRANSFER CABINET
7. REGRIGERATING UNIT UNDER LOADING COUNTER
8. DRAWERS UNDER COUNTER
9. FILM BIN UNDER COUNTER
10. DEVELOPING TANK
11. RINSE OR ACID SHORT-STOP
12. FIXING TANK
13. RINSE TANK
14. PREWASH TANK
15. WASH TANK
16. OVERHEAD LIGHT
17. SAFE LIGHT OVER DEVELOPER TANK
18. VIEWING LIGHT OVER WASH TANK
19. TIMER ON PANEL



TRANSFER CABINET



DARK ROOM LIGHTS

The safelight should be at least two feet from loading bench.

Safelights may be tested by placing an unexposed film, partially covered with black paper on the loading bench and exposing for five minutes to the safelight. When the film is developed any fog will indicate that the light is too strong or the filter incorrect. Films are much more susceptible to safelight fog after they have been exposed.

For X-ray work, a Wratten 6 B filter is usually recommended and is quite satisfactory. This filter is absolutely unsuited for photographic emulsions because these are usually orthochromatic and accordingly sensitive to the reds and oranges as well as to the colors which show more actinic value.

Timers: The time-temperature method of processing calls for accurate timing. Mechanical or electrical interval timers are thus needed. Sight development should be avoided. Post a time temperature chart in a conspicuous place and observe temperature at regular intervals.

Thermometers: Tank thermometers are customarily graduated in the Fahrenheit scale and should be compared with a test thermometer. If a centigrade thermometer must be used, prepare a conversion table. To obtain temperature in degrees Fahrenheit, multiply the centigrade temperature by 9/5 and then add 32.

By formula: Degrees F = (degrees C x 9/5)plus 32.

Note: Be sure never to add the 32 degrees before multiplying.

Processing tanks: It is necessary to know or determine the actual capacity of the tanks to insure solutions of proper strength. This may be determined by measuring the three inside dimensions in inches. These three dimensions are multiplied together in order to obtain volume in cubic inches. This divided by 231 will give the capacity of the tank in gallons.

Refrigeration and Water Supply: There should preferably be a supply of hot and cold water regulated by a mixing valve to maintain proper solution temperatures. Chilled water is usually needed in hot weather and regular units are available to provide such. Occasions may arise for developing when no incoming cold water is available. The solutions may then be cooled by placing blocks of ice about the tanks. Never put ice in the developer or fixer as this will weaken the solutions.

Another method is to place the solutions in containers and store them in a refrigerator over night. Again some developer may be frozen in refrigerator trays and used to chill the remainder of the developer in the processing tank.

Emergency may call for processing in hot weather when neither refrigeration or temperature control of solutions by ice is possible. In that event, remove films from fixer soon after clearing and cut washing time down to 8 to 10 minutes. (See notes on hot solution processing). These films will not last well but films of poor lasting quality are better than complete ruin. (See also notes on special solutions).

Dryers: These make use of dry heated air to speed drying. The temperature is usually satisfactory and trouble is not apt to develop unless the exhaust fan fails or the ventilating outlet is blocked. Dryers should have dust cleaned from the heating element and fan blades periodically. In addition the motor requires an occasional oiling.

Film bin: Film bins must be light proof and be lead-lined to protect films from X-ray. They are best mounted under the loading bench and should be divided into suitable sections to accommodate the various sizes of film. If a bin is not available, use a lead-lined chest. The size of the film bin compartments should be adequate to accommodate slightly more than a half-gross of film, because film often comes in 1/2 gross containers. The front of the film bin should be stenciled: "X-RAY FILMS - DO NOT OPEN IN LIGHT".

Loading bench: The loading bench should be at least 20 inches wide and 36 inches long to allow adequate work space. Keep all chemicals away from it to prevent access to films or screens.

Storage space: There should be adequate storage space in the form of shelves or bins for holding cassettes and cardboard holders; also a suitable cabinet for storing chemicals, scales, graduates, etc.

Transfer cabinet: A two-way lead-lined cabinet, one side for exposed, the other for unexposed films, should extend from one side of the loading bench through the wall into an adjoining radiographic room for convenience and efficiency in transferring exposed and unexposed films to and from the darkroom. It should have mechanical means to prevent both doors from opening at the same time. Otherwise a bad leakage of light or X-ray, or both, may occur with resultant "light struck" or fogged films.

Ventilation: One or more windows are desirable so that a periodic airing can be easily accomplished. However, the windows must be closed and blacked out most of the time and special means of ventilation should be provided. An exhaust or supply fan will answer. If the dryer is located in the darkroom and has its exhaust vented into a duct that leads outside, it will accomplish ventilation.

Maze: If the maze is provided with a sliding partition instead of a fixed wall, convenient access for installation or removal of bulky equipment will thereby be provided. Its reflecting surfaces should be dark colored.

Walls: Special paints are available and are satisfactory but nevertheless any ordinary flat buff, gray or greenish color, etc. will answer. Tiling is a good measure.

System: A definite system should be maintained in the darkroom for handling film holders and cassettes. A good plan is invariably to place cassettes face down on loading bench when they contain exposed film, and face up when they have been reloaded. In addition place the reloaded cassettes at once in the side of the cabinet for unexposed film or in other regular storage places.

If in emergency, cassettes or holders must be reloaded without processing

the exposed films, place the films in the loading bin in front of other films and minus the black paper. They will then be easily identified when it is possible to process them.

COMMON TROUBLES:

Most trouble, on investigation, will be found to be consequent upon some type of carelessness or neglect. Many workers fail to realize that meticulous cleanliness, careful work, close observation, orderly and systematic habits and an acute sense of responsibility are truly essential. It is all too easy to be slip-shod, neglect observation of temperature, spatter solutions, neglect rinsing, handle things roughly, put off replacement of solutions and mix them carelessly and so on.

A list of common troubles is as follows:

1. Black crescent marks: These are due to crimping of the films by the thumb while loading the films into holders or cassettes. The cure is obvious.

2. Scratches and abrasions: Cause and prevention need little comment. Remember that wet films are easily damaged. Don't overcrowd tanks.

3. Reticulation or fine puckering: This is due to uneven swelling of the gelatin caused by marked difference in the temperature of processing solutions, e.g., cold fixer and warm rinse water.

4. Melting of emulsion: This is apt to be due to high temperature of wash water, or leaving a wet film in front of an illuminator too long.

5. Pressure marks: These may result from prolonged storage of films in horizontal position. Store film boxes on edge.

6. Finger marks: Dirty or damp fingers are the cause. There is no excuse for this.

7. Comet spots: These are due to undissolved particles of developing chemicals settling on the emulsion. Prevention: Don't use solutions until they are entirely clear.

8. Clear Zone at one end of film: There has been "low tide" in the developing tank and the cure is simple.

9. Rounded clear areas in film: A lazy man's load has overcrowded the developing tank so that films have come into contact wherever there has been the least bulge. Reduce number of films handled at one time and see that the hangers keep the films evenly stretched.

10. Large round milky areas: This time the overcrowding has been in the fixing bath and where areas have come in contact clearing naturally could not take place. These spots will eventually turn dark brown.

11. Tiny clear spots: Lack of a little agitation permits a few air bubbles to cling to the emulsion during developing.

12. Oily film surface: Due to incomplete washing, some hypo remains in the emulsion and attracts water from the atmosphere giving the film a greasy feel and oily appearance.

13. Tiny elevations: Such films have been hastily plunged,without sufficient rinsing, into a fixer or "short-stop" of rather strong acidity. Effervescence with liberation of small amounts of gas under the emulsion, produces the tiny bumps. To prevent, use a fixing bath or short-stop of correct acidity. If no short-stop is used, rinse well.

14. Streaks of varying density: These result from excessive inspection during the developing period either as a result of too much curiosity or over anxious attempts at sight development. Some fog is apt to be present also.

If "sight" development should be necessary (and such should not be a frequent occurrence) one should delay inspection for a few minutes as most harm can be done in that period. Then inspection should be brief. Needless to say the eyes should be well adjusted to the dark and be it remembered this requires at the very least, five minutes.

15. Metallic appearing deposits on film: These are usually due to oxidation products from developer. Prevent by keeping solutions covered. If a regular lid is not provided it is simple to make floats to cover solution, from paraffin dipped layers of paper or paraffin dipped cedar.

16. White scum: This is due to "milky" fixer. This may be due to:

(a) Solutions too warm when mixed.
(b) Solutions mixed too rapidly or without sufficient stirring.
(c) Failure to dilute acid before adding.
(d) Use of too little Sodium Sulphite.
(e) Carrying too much developer over into the fixer as the result of poor rinsing or lack of short-stop.
(f) Unsatisfactory water supply. Try distilled water if evidence points to this cause.

17. Yellow stains: This is usually due to long development in old developer.

18. Fog: This is most often due to one or more of the following:

(a) Light leaks.
(b) Stray radiation.
(c) Wrong filter in safelight or bulb of more than 15 watts.
(d) Faded filter. (Usually due to overheating from bulb of high wattage).
(e) Overdevelopment or prolonged development in old or exhausted developer.
(f) Careless sight development.
(g) Contaminated developer (as from spilling fixer in it).
(h) Storage of film in warm place.
(i) Out-dated film.
(j) Viewing radiograph before completely cleared.

(k) Films exposed to safelight too long; also common cause of hanger shadows. No safelight is entirely safe.

19. Static marks: These are of several varieties, chiefly tree forms, rows of dots and smudges. They are most apt to occur in the cooler months when heat is turned on with resultant drying of the atmosphere. When this trouble arises try the following:

(a) Avoid rubber soled shoes.
(b) Do not pull films from the black paper covers. Let the paper fall away from the film.
(c) Ground the loading bench.
(d) Mop floor frequently to moisten air.

QUESTIONS:

1. State the composition of photographic emulsions.
2. What is the effect of actinic light and of X-ray on photographic emulsion?
3. What base is used for X-ray films and why?
4. What precautions should be taken in regard to storage of unused X-ray film?
5. In what way does a radiograph differ from a photograph?
6. What is the purpose of screens?
7. What is a cassette?
8. What are the essential substances used in the coating of screens?
9. Why is perfect contact between screens and films necessary?
10. How do you test for good contact?
11. List the main ingredients of X-ray developer.
12. Describe the action of each chemical.
13. List the main chemicals used in fixing baths and state the purpose of each.
14. Discuss methods of hot solution processing.
15. Describe in detail the processing of a film.
16. Describe how to test the safety of a darkroom safelite.
17. State the main objections to sight development.
18. State the cause of the following types of defective radiographs: (1) Dark crescent mark; (2) Reticulation; (3) Comet spots; (4) Large, round milky areas; (5) Oily film surface; (6) Static marks; and (7) Fog.

RADIOGRAPHIC TECHNIQUE

FACTORS

The aim of radiography is of course the production of good radiographs. Within the limits of good diagnostic quality there is room for variation in the degree of contrast and density to suit individual preference. However, it is possible to say that a satisfactory radiograph should show:

(a) Fine detail or definition.
(b) Ample contrast.
(c) Little distortion.
(d) Sufficient density.

To secure these qualities in the greatest possible degree we must take into account a number of factors and hence there is no escaping some complexity.

In the first place we must make provision for varying thicknesses. Obviously one can say, that should be easily and quickly disposed of by changing the quantity of X-ray. As a matter of fact that can be and is done. However, there is also the matter of qualitative difference in the X-ray. As pointed out previously the X-rays produced by currents of low K.V.P. are softer or less penetrating than the high voltage X-rays. Thus it can readily be seen that highly penetrating rays may cut through all tissues so completely as to yield little contrast. On the other hand very soft rays may be blocked almost completely by soft tissues. Thus in the interest of good contrast and proper density, variations in K.V.P. are embodied in nearly all techniques. When in the interest of simplicity or by reason of necessity (small units of fixed or narrow range of kilovoltage) it is desired to work with little or no change in K.V.P. a compromise voltage has to be employed, (about 65 K.V.P. will answer this purpose well). Then, of course, the varying requirements are met by changing the time, milliamperes or both to get the required amount of radiation.

There are three main variables or prime factors concerned as regards the Roentgen Rays themselves.

1. <u>Milliampere seconds.</u> (M.A.S.) This is product of milliamperes of tube current and the time of exposure in seconds. Thus 100 M.A. for 2 seconds results in 200 M.A.S. and 100 M.A. for 0.1 seconds results in 10 M.A.S. This factor affects radiographic density in direct proportion to its amount.

2. <u>Kilovoltage.</u> (Kv. or K.V.P.) is spoken of in terms of peak values. Because of the effects of voltage on penetration, as noted previously, kilovoltage is usually spoken of as the penetration factor. In most standard techniques a fixed M.A.S. value is determined for each part to accord with a satisfactory kilovoltage range that provides for variations in the thickness to be penetrated.

Kilovoltage also has a marked effect on general exposure as the following table will indicate:

EFFECT OF K.V.P. ON EXPOSURE

To Decrease Exposure Time	Increase Kilovoltage With Double Screens	Increase Kilovoltage Without Screens
25%	7%	15%
50%	20%	40%
75%	50%	100%

To Increase Exposure Time	Decrease Kilovoltage With Double Screens	Decrease Kilovoltage Without Screens
25%	5%	10%
50%	10%	18%
75%	13%	25%
100%	16%	30%

3. Distance. This term refers to the distance between the target of the X-ray tube and the film. Intensity follows the law of the inverse square. Thus when distance is doubled, radiographic intensity will be reduced to 1/4th.; or to put it another way 4 times as many M.A.S. will be required for the same effect. Correction for varying distances is thus relatively simple to calculate. However, to conserve time and prevent error from hurried mathematics it is a good idea to have a table of correction at hand for easy reference.

For most work distances of from 25 to 40 inches are used. For chest work 72 inches is preferred.

M.A.S. FACTORS FOR VARIOUS DISTANCES

Initial Anode-Film Distance	Factors							
20 inches	1.0	1.6	2.3	3.2	4.0	5.8	9.0	13.0
25 "	.64	1.0	1.4	2.1	2.6	3.7	5.8	8.3
30 "	.44	.69	1.0	1.4	1.8	2.6	4.0	5.8
36 "	.31	.48	.69	1.0	1.2	1.8	2.8	4.0
40 "	.25	.39	.56	.81	1.0	1.4	2.3	3.2
48 "	.17	.27	.39	.59	.69	1.0	1.6	2.3
60 "	.11	.17	.25	.36	.44	.64	1.0	1.4
72 "	.08	.12	.17	.25	.31	.44	.69	1.0
New Anode-Film Distance	20"	25"	30"	36"	40"	48"	60"	72"

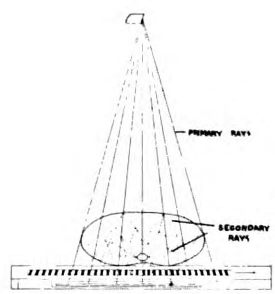
Another factor which is of the greatest importance in exposure technique is of course the thickness of the part to be radiographed. As noted before varying of M.A.S. or K.V.P. or both will be involved. This, however, is not the whole answer. When one inspects radiographs made in the ordinary manner either with the films in plain cardboard holders or in cassettes, it will be noted that as the parts become thicker the films lose brilliancy and show more or less diffuse fog. This is due to the inevitable increase in secondary radiation, and becomes seriously objectionable when the parts reach a thickness of about 10 cms. To overcome this a number of methods are in common use.

1. Cones, cylinders and diaphragms.
2. Moving grids - called "Potter-Bucky" Diaphragms or simply "Buckies".
3. Stationary grids called Lysholm, Swedish or Wafer grids.

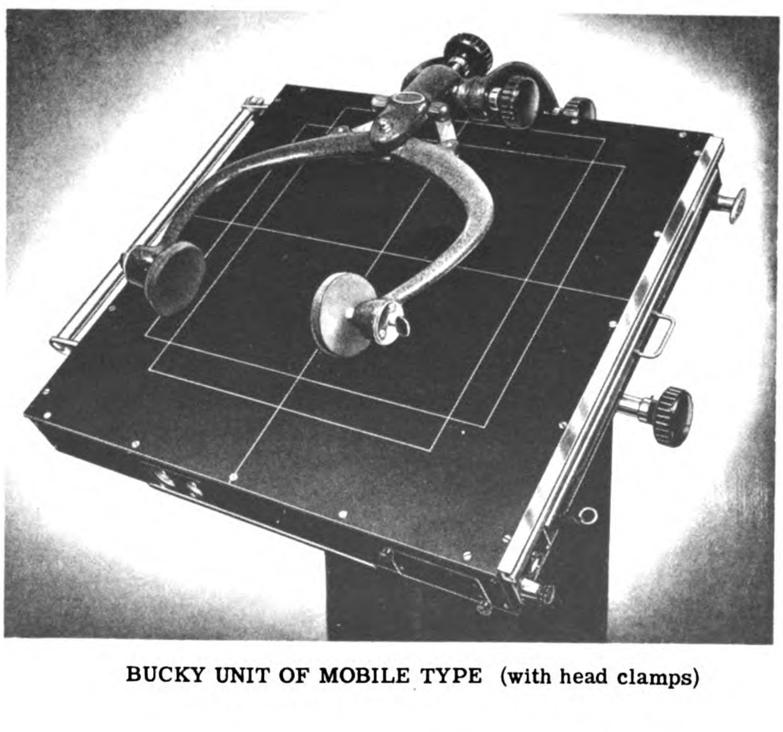
ASSORTED CONES

CYLINDER

A STATIONARY GRID



PRINCIPLE OF POTTER-BUCKY DIAPHRAGM



BUCKY UNIT OF MOBILE TYPE (with head clamps)

Cones, Cylinders and Diaphragms:

These are attached to the tube head and naturally serve to cut out divergent rays to a greater or less extent depending on size and distance from the body. The smaller the aperture and the smaller the distance from the aperture to the plate the more divergent rays will be cut out. The result is that by use of these we can get brilliant views of thick parts. The drawback is that the size of the field is necessarily reduced. Small cones call for a slight increase in exposure. Diaphragms are shields with limiting apertures and are placed immediately below the tube to cut off divergent rays. They serve the same purpose as cones and cylinders. However, cones and cylinders are more efficient, easier to work with and in addition they point the path of the central ray, indicate distance and render easier the estimation of the field that will be covered. They can also be readily marked with a scale of plate coverage for various distances.

As noted above the main objection to cones and diaphragms is the decided limitation of the field covered when one wishes a clear view of a thick part. To obviate this difficulty grids are made use of.

The "Bucky" grid or "Potter Bucky" Diaphragm:

This is constructed of alternate strips of wood or other suitable material and lead and is arranged to move at right angles to the long axis of the strips while an exposure is being made. The distance it moves is slightly over 3 inches and the speed can be varied to suit various exposure times. A frequent speed range is now for exposures of from 1/10 to 30 seconds. Fast Buckies show a range of from 1/20 to 10 or 20 seconds. The number of lead strips per inch is usually about 29. However, many modern Buckies have 50 strips per inch.

The ratio of the height of the lead strips to the space between them is called the Grid Ratio and is most often 5 to 1. Some Buckies are built to operate at 48 inches, have an 8 to 1 ratio.

The strips of lead are arranged to cut out secondary rays and at the same time cause as little interference as possible with direct rays. If the tube is off center laterally more than an inch or so, or if the distance is varied beyond the proper range (usually 30-40 inches) the amount of direct radiation intercepted will increase to a notable degree. The efficiency of the Bucky as a means of preventing secondary radiation is quite high. Three times the usual exposure is required. Angulation of the X-ray tube is permissable parallel to the long axis. Increased exposure is commonly accomplished by increasing both time and kilovoltage. A few fast Buckies are designed to work on double the usual exposure and are used chiefly for chest work.

The object of the grid motion is, of course, to prevent grid lines on the films. If any show, the cause is apt to be one or more of the following:

1. X-ray exposure before the grid starts or after it stops. Proper timing will prevent this.

2. Very slow grid speed with fast exposure.

3. Faster exposures than grid is designed for.

4. Synchronization of X-ray impulses with speed of Bucky so that as each X-ray impulse reaches the film a set of grids will be in the same position relative to the film. To remedy this change time a trifle. Exposures under 1/2 second are usually involved, particularly 1/5 seconds.

5. Failure of grid to move or irregular jerky motion of grid.

In the old models the Bucky after being "cocked" and timed, is tripped by hand and then the exposure started as a separate operation. In later models, however, electric contacts are included to provide automatic opening and closing of the high tension circuit; also an electromagnetic release. Thus the whole Bucky exposure is made by pushing one button. Since timing devices on the Buckies are not as accurate as the motor driven timers on X-ray machines and moreover vary with temperature, the modern practice is to link the Bucky and X-ray timer. The result is that when the Bucky release button is pushed, the grid starts its traverse and promptly closes an electric contact to the timer causing it to make whatever exposure it is set for. The Bucky timer,of course, is set for a slightly greater interval than the X-ray timer, usually 1/4 to 1/2 second more.

Stationary grids:

These are variously spoken of as Lysholm, Swedish and Wafer grids. They are made on the same principle as the "Bucky" grid but have finer strips usually 0.04 mm. in thickness and with spaces of the same size. They are convenient to use when the Bucky is impracticable, as in bedside work. They are highly efficient and are suitable for both fluorography and radiography. The grid shadows are naturally always present on the film but are not objectionable when the films are viewed at the usual distance. The increase in exposure required for the stationary grid is approximately the same as the "Potter Bucky" diaphragm. Various sizes are obtainable.

In choosing which of these methods to use, one is, of course, guided by circumstances as well as preference. In well equipped radiographic rooms the Bucky is generally used for heavy work. For sinuses and mastoids which can be included in small fields, many prefer cones or cylinders at all times since detail is finer and distortion less due to the closer approximation of part and film.

For bedside work, cones, cylinders, diaphragms and Lysholm grids are all practical.

It should, of course, be remembered that cones of proper dimensions for adequate coverage will also improve grid pictures.

Non-Screen Film:

In addition to the above there is also a choice in film. Non-screen film can replace regular films to advantage in certain types of work. This film has a high speed emulsion of great latitude, adapted to direct radiation but comparatively

insensitive to light from fluorescent screens and so unsuitable for use with such. It is most useful for extremity work and may be used with a grid for shoulders, knees or other parts not too thick, with excellent results. It is, of course, possible to use it for heavy parts but the exposures called for will be somewhat excessive because screens cannot be used.

The effects of secondary radiation are greatly pronounced with this film and the use of cones and diaphragms is more important than ever.

The speed is at least three times that of regular X-ray film and so non-grid exposures are lessened accordingly. Grid exposures on the other hand, since screens are omitted, increase markedly (about 5 times). The increased exposure is usually obtained by increasing both the M.A.S. and the kilovoltage.

These films require about 60% increase in developing time and so instead of 5 minutes at 65 degrees F. 8 minutes will be required. They also require slightly more time to clear after being placed in the fixer.

X-ray Controls:

A final and important consideration in the production of good radiographs is accuracy as to M.A., time and K.V.P.

The first of these (milliamperage) is registered by a milliammeter placed either on the control panel or suspended from a high tension aerial. It is of course a simple matter to read it, but it should be remembered that many of these meters have both a high and low scale so that it is necessary first to adjust the scale according to the M.A. to be measured.

To properly measure currents of more than 100 M.A. another type of meter is used, namely, the Ballistic milliammeter or milliampere second meter. This records the actual milliampere seconds of brief high capacity exposures. Tube capacities will not permit of sufficiently long exposures for the usual milliammeter to register correct readings.

Calculation of the milliamperage is readily accomplished from the M.A.S. by dividing the M.A.S. by the time, e.g., if an exposure of 1/30 second yields 16 M.A.S. we simply divide 16 by 1/30. The rule for division by fractions is to invert and multiply. Thus we replace $16 \div 1/30$ by $16 \times 30/1$ which gives us 480 M.A.

Again if we use decimals it is only necessary to watch the decimal point. If an exposure 0.05 seconds gives us 25 M.A.S. then we have the easy problem of:
25.00 divided by 0.05 or 0.05/ 25.00
500 M.A.

Regulation of the milliamperage is by means of the filament current and this is measured by an ammeter. For each tube, a group of settings is charted so that when a given milliamperage is desired, one can closely approximate the correct figure by adjusting the tube filament current to the proper amperage. As exposures are made a glance at the milliammeter will, of course, indicate any changes that might be needed.

In many modern machines the milliampere settings are prearranged in a "technique selector" or "monitor" system. In using such remember to read the milliammeter just the same. Inaccuracies may be present or develop that will require adjustment.

Timers:

These are usually accurate enough but an occasional test with the "spinning top" is worth while. This top has a metal disc with a single small perforation near its edge. Thus as it spins over a film during an exposure each X-ray impulse will produce a dot. In a fully rectified circuit there will be 12 dots for each tenth of a second, if the usual 60 cycle A. C. current is used. A self rectified or half wave rectified circuit will give 6 impulses in 0.1 seconds.

Kilovoltage:

Many machines have a voltmeter which reads the voltage obtained from the autotransformer or else is calibrated in arbitrary figures. Meters are not available to record the high potentials used in the secondary high-tension X-ray circuits. The result is that the voltmeter must be calibrated in terms of kilovoltage for each milliamperage used, as the readings will differ. When high milliamperage is used more energy must be obtained from the autotransformer to attain a given kilovoltage, than if a low milliamperage is used. Thus more coils must be thrown into the circuit. Manufacturers supply charts to indicate the readings of the voltmeter for whatever K.V.P. is desired at the various milliamperages in general use and within the capacity of the machines. Nevertheless it is good practice to verify the chart by sphere gap readings when practicable. (See sample chart, page 229).

Shock Proof apparatus requires special adapters, and high capacity currents call for special precautions and procedures so that the use of the sphere gap is becoming more and more inconvenient. In lieu of the sphere gap it is possible to obtain an idea of how a machine is performing by comparing its exposure figures with those of another machine. In addition, and especially when high capacity apparatus is involved, one should take comparison views of some object, preferably an aluminum stepladder or Benoist penetronmeter using the same K.V.P. and M.A.S. but obtaining the M.A.S. with varying times and milliamperages. If the radiographs differ in density inaccuracy is indicated. It is not uncommon to note a deficiency at high settings, but before ascribing such to the Roentgen apparatus investigate power conditions. The main line or "pole" transformer may be of insufficient capacity or the lead-in wires may be too small or unduly long. Most new machines now show the actual K.V.P. figures on a meter or on the auto-transformer controls. This is made possible by special wiring systems and a compensating adjustment. The figures may not always be accurate and so it is well to make radiographic tests as described above. Errors will of course be compensated for by variation in exposure factors when the machine has its exposure chart built up. However, any large errors should be corrected in the interests of accuracy and to keep the exposure technique in general agreement with other similar machines.

To summarize briefly the main radiographic factors the following table is included:

1. Fine Detail. (Also spoken of as good definition or sharpness).

(a) Focal spot.
Small focal spot permits sharper detail within limits of grain of film and intensifying screens.

(b) Distance between part and film.
The closer the film to the body part, the better the detail.

(c) Screen film contact.
As noted previously, perfect contact is necessary to prevent blurring.

(d) Absence of motion on part of patient, film or tube.

(e) Absence of film fog.
This involves use of fresh films, precautions against stray and secondary radiation and correct dark room procedure.

2. Minimum distortion.

(a) Long target film distance lessens distortion.

(b) Short distance between film and part lessens distortion.

(c) Accurate centering is necessary.

3. Contrast.

(a) Low kilovoltage increases contrast.

(b) M.A.S. in correct amount is essential.

(c) Screens increase contrast.

(d) Grids, cones and diaphragms, as well as precautions against stray radiation, improve contrast and lessen fog.

(e) Correct dark room technique.

4. Density.

(a) Kilovoltage. The higher the K.V.P. the greater the density.

(b) M.A.S.: More M.A.S. means greater density.

(c) Distance. Law of inverse square.

(d) Screens. These greatly increase density.

(e) Film. Fresh active film should be used.

(f) Processing solutions. Old, cold, exhausted or contaminated developer impairs density.

<u>EXPOSURE TECHNIQUE:</u>

With the foregoing in mind we are now ready to consider the technical details of actual radiography. First of all, we have to decide as to the use or not of plain holders, screen, grids, cones, etc.

Satisfactory extremity views can be made with regular film in ordinary cardboard holders, or in double screen cassettes. In addition special non-screen film is available. Screens increase contrast and lessen exposure. Plain films show slightly better detail and are free from the little imperfections frequently seen in screen films. In general when apparatus of good capacity is available, the use of films in plain holders is preferred for extremities. When machines of 10-15 M.A.S. capacity are used, as in bedside work, aboard ship or in small dispensaries, screens are commonly used so as to avoid long exposures. Again in radiographing infants and small children, speed is highly essential and here screens become indispensable. In soft tissue work screens are preferred as maximum contrast is necessary. For thick parts where small cones, diaphragms, Buckies or grids are used, screens are of course necessary. In general the matter sums about as follows:

Hand Wrist Forearm Elbow Humeral shaft, lower portion Foot Ankle Lower leg	(a) Regular film in plain cardboard holders usually preferred. (b) Use screens with low capacity machines and also if total exposure of part is becoming high.(particularly if there has been extensive fluoroscopy). (c) Special non-screen film if desired or available.
Knee Shoulder and upper end of humerus Femur	(a) Bucky or Lysholm grid used with double screens, very satisfactory. (b) Cones, cylinders and diaphragms will also produce excellent results either with or without screens.
Spine and Pelvis	The Bucky or Lysholm grid generally used except where small areas are under consideration permitting "spot" films by means of small cones or cylinders.

looks for a dial to govern the amperage of the tube filament, also an ammeter and a chart to state what milliamperage will be produced by the various filament settings. On modern automatic types of machine, one looks for a dial or other indicator marked directly with the milliamperes that should be obtained and some type of compensating adjustment meter. Usually a knob or handle is turned until the needle of the meter is over a specific line marked in red. Naturally a milliammeter and perhaps a ballistic meter, should be present.

K.V.P. is governed by the autotransformer controls. Major and minor steps are provided and so we look for two knobs or handles to take care of adjustments. There is also often a pre-reading voltmeter with a calibrator chart to indicate the voltage necessary to produce the K.V.P. desired. Again in modern types the control panel may give direct K.V.P. values.

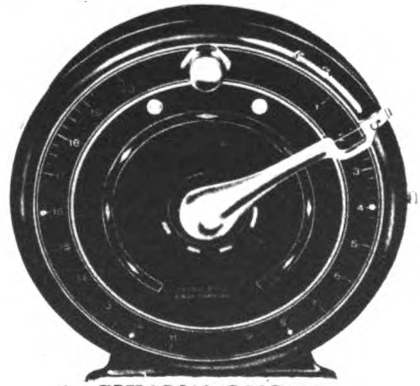
A timer is always present and it should be noted whether or not it has a long and short scale adjustment. In addition - an impulse timer for short exposures is nearly always present on high capacity machines. These timers usually range from 1/120 second (one impulse) to 1/4 second. X-ray circuits are usually so arranged that only this timer can be used on high capacity settings. If this is not the case there is marked danger of damage to the tube by an overload.

The regular timers are usually driven by a synchronous motor and cover a range of from 1/20 to 30 seconds. On small units (bedside and dental) hand timers run by a clock-work mechanism, are made use of.

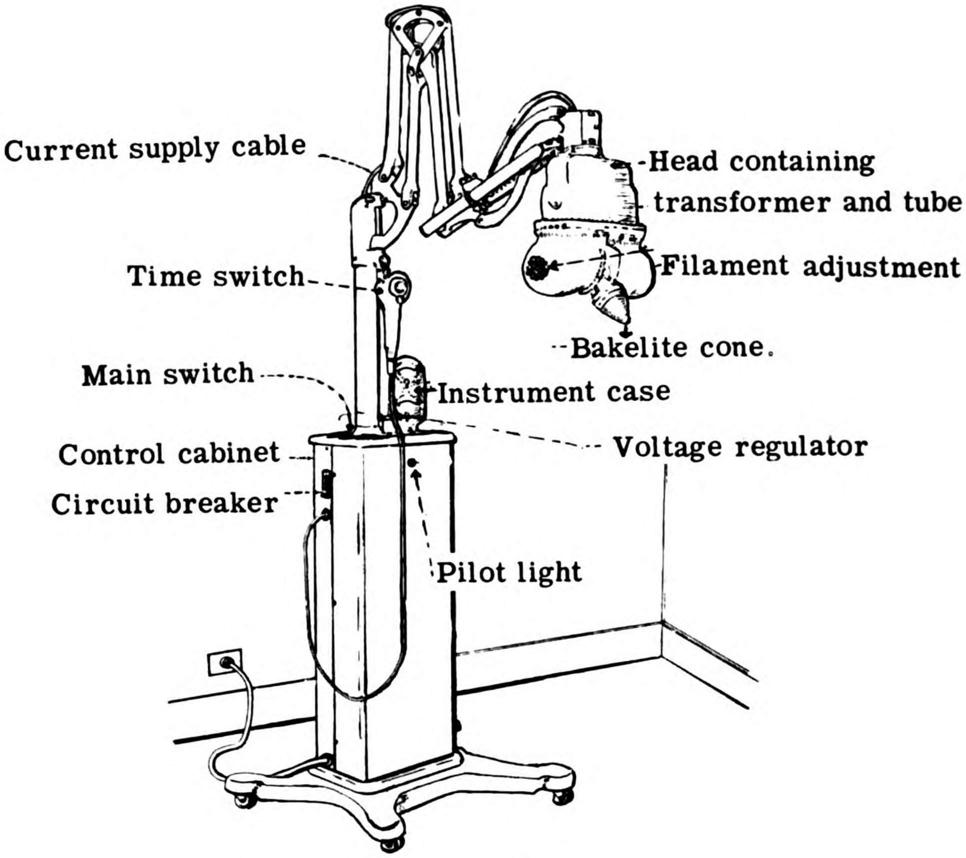
In addition to these fundamental controls there will usually be Bucky release buttons; perhaps a rheostat; a circuit breaker button; a meter to show valve tube current; release buttons for stereoscopic shift mechanisms; hand switch for the X-ray; a technique selector dial or some type of capacity selector that will adjust the machine so that only low M.A. can be obtained when fluoroscopy or therapy is desired and again so that high capacities are limited to the impulse timer; various indicator lights; a switch to throw Buckies in or out of circuit; main line switch,etc.

The control board, needless to say, should be studied carefully so that one can, as the saying goes, "run it in his sleep". A vast amount of trouble arises from failure to follow this very elementary and basic rule.

TYPE OF CONTROL UNIT

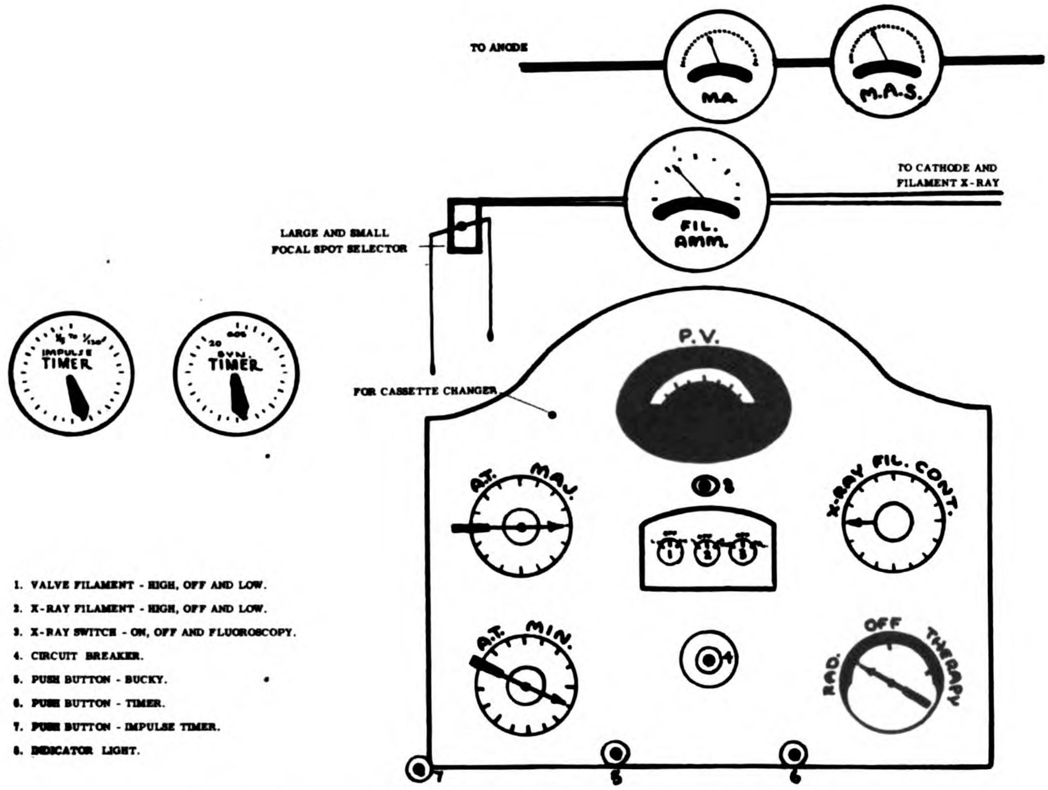


SYNCHRONOUS TIMER

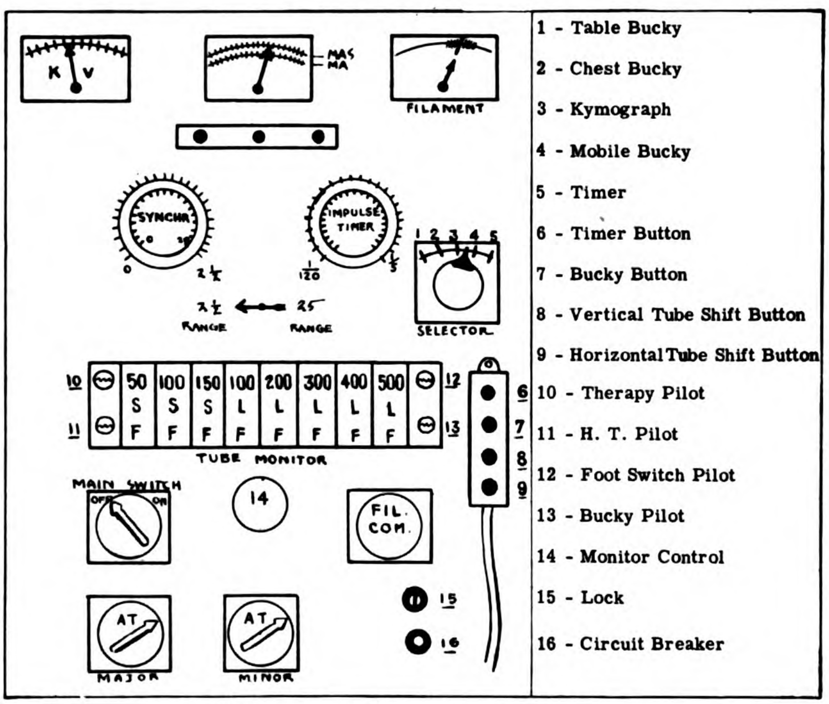


TYPE OF DENTAL X-RAY

CONTROL OF MOBILE BEDSIDE UNITS



OLDER NON-AUTOMATIC TYPE OF CONTROL



MODERN TYPE OF CONTROL

This brings us to the determination of the actual exposure factors to be used in a given case. For this purpose various guides and charts are available and in each radiographic room a technique chart will usually be found. Occasionally it may be necessary to start from scratch or one may be dissatisfied with the chart on hand and wish to start over. In this case one can proceed as follows:

On the basis of previous experience or other data it is relatively simple to determine a promising starting point for each section of the body and for various thicknesses. Thus one can start with an extremity of minimum thickness (the hand is quite convenient) and make a series of exposures at varying kilovoltages, the other factors remaining constant. From the views thus obtained the most satisfactory is picked. The kilovoltage used in its production is then recorded and forms one fixed starting point. A second fixed point is obtained in similar fashion for a thicker part of about 10 cm. These two points can be marked on graph paper on which kilovoltage is marked out on the side and centimeters along the bottom. A line connecting the points will indicate proper kilovoltage for any thickness. This method can be applied to heavy parts in which grids are used for any modification of procedure desired. Usually it will be found that each increase of 1 cm. calls for about 2 K.V.P. or a trifle more, increase in potential.

It might also be noted that if one is in doubt as to what kilovoltage to start with, a rule that will usually afford a satisfactory result is: Double the thickness of part in cms. + 30 = proper kilovoltage.

The M.A.S. to employ might well be about as follows:

Extremities, regular Film - no screen	100
” ” ” Double screens	10
Smaller parts with Bucky and Double Screens	60 - 100
Spine, skull, pelvis A.P.	75 - 150
Lumbar spine Lat	250 - 300
Gastro-intestinal tract	60 - 100
Urinary Tract	60 - 100
Gall Bladder	60 - 100
Chest P.A. (6 ft.)	10 - 20

Further variation is of course permissible. For non-screen film one might try 30 to 50 M.A.S. for extremity work. For Bucky work (remember no screens are used with this type of film) the M.A.S. might remain the same but about 15 - 20 K.V.P. more will be required.

If a trial run produces no satisfactory films it is first necessary to make sure that the exposure factors are adequate, the machine operating properly, the X-ray tube is in good condition and also that no dark room errors are at fault.

Assuming that any gross errors are ruled out, the problem will usually resolve itself into obtaining a proper balance of M.A.S. and K.V.P. If films appear gray and lacking in contrast, increase the M.A.S. and lower the K.V.P., e.g., increase M.A.S. 50% to 100% and decrease potential by 5 to 10 K.V.P.

On the other hand if there is good general density with poor bone detail, use more K.V.P. and less M.A.S.

Another simple and practical procedure is to merely adjust a suitable exposure technique chart such as those furnished by various manufacturers and in various texts, by making a few trial exposures to indicate what shift, if any, may be necessary in the exposure factors. A K.V.P. scale can be readily shifted up or down relative to the thickness in cm.

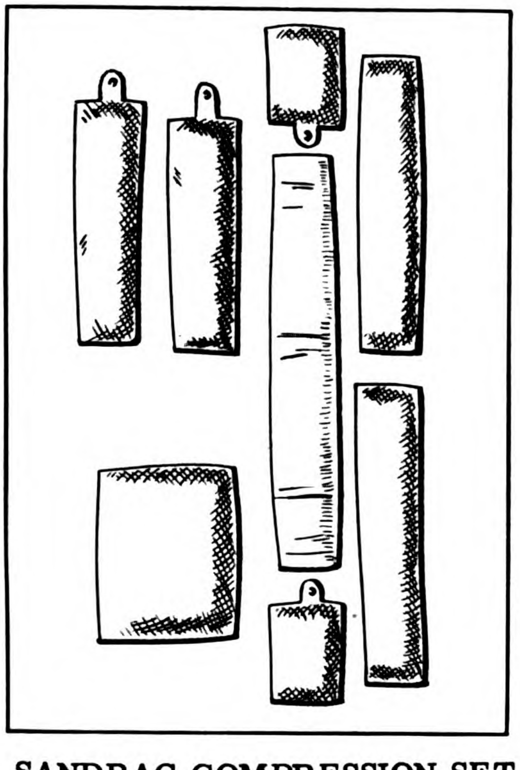
Several technique charts are listed below. They have been in actual use and produced satisfactory results. Several blank charts are included.

1. Exposure chart as adapted to high capacity 3 phase unit with Rotating anode. With appropriate alteration this chart can be used for any X-ray machine with a variable kilovoltage. A slight increase in K.V.P. may be needed and in the case of small machines exposures will have to call for less M.A. and more time.

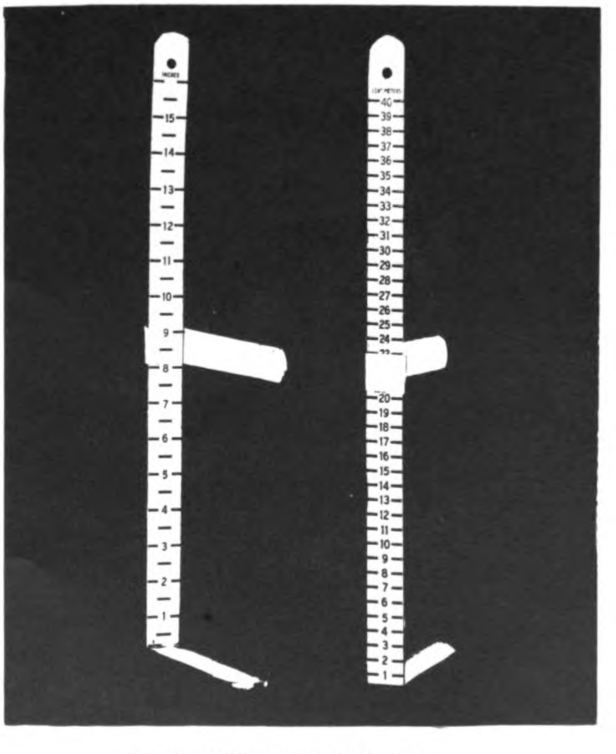
2. Technique charts applicable to various type units as supplied by Westinghouse X-ray Company.

3. Fixed Kilovoltage technique. This is especially for units with little or no kilovoltage control; also adaptable to other machines including high capacity units. 85 to 100 K.V.P. favored by some workers, especially for Bucky radiography.

Experienced technicians may wish to go in for greater refinement of technique than is exhibited in the charts. This can be done by determining along the lines already described, the desired balance between M.A.S. and K.V.P. for each part or as many classes of parts as may be wished.



SANDBAG COMPRESSION SET



X-RAY CALIPERS

X-RAY DEPARTMENT, NATIONAL NAVAL MEDICAL CENTER.

RADIOGRAPHIC TECHNIQUE

Chest-Heart-Esophagus	B'KY	MA SEC.	SEC. AT MA	DIS.	cm. 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
CHEST and HEART P.A.	NO	20	1/20 400	72						44	47	49	52	53	55	57	59	61	63	65	68	71	73	76	79	82	85	87	90	
CHEST and HEART OBL.	NO	20	1/20 400	72					ADD		10	KV.	TO	PA.																
CHEST and HEART LAT.	NO	50	1/4 200	72					ADD		15	KV.	TO	PA.		FIGURE OR TAKE ACTUAL MEASUREMENT														
RIBS ABOVE DIAPHRAGM	NO	20	1/20 400	72					ADD		4	KV.	TO	PA.																
ESOPHAGUS	NO	33	1/15 500	72					ADD		10	KV.	TO	PA.		FOR EITHER A.P. OR OBLIQUE.														
INFANTS CHEST	NO	7.5	1/40 300	39						55	TO	65																		

Extremities	B'KY	MA SEC.	SEC. AT MA	DIS.	cm. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
SMALL PARTS - NON SCREEN	NO	100	1-100	36	42	44	46	49	51	53	56	59	61	64	67	70	73	76	78											
SMALL PARTS - WITH SCREEN	NO	10	.1-100	36	36	38	40	42	44	46	49	51	54	57	60	62	65	67	70											
PARTS 10cm and over WITH SCREEN	Y'S	100	.5-200	36					38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68						
SPECIAL NON SCREEN FILM	NO	40	4-100	36	42	44	46	49	51	53	56	59	61	64	67	70	73	76	78	DEVELOP FOR 8 MIN. AT 65° F.										
SPECIAL NON SCREEN FILM	Y'S	120	1.2-100	36																										

Head	B'KY	MA SEC.	SEC. AT MA	DIS.	cm. 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
SKULL	Y'S																													
SINUSES	Y'S	100	.5-200	36	48	50	52	54	56	58	60	62	64	66	68	70	72	74												
MASTOIDS	Y'S																													
SINUSES (CONE OR CYLINDER)	NO	75	1/4-100		43	45	47	49	51	53	55	57	59	61	63	65	67	69	72	75	78	81	84							
MASTOIDS and VARIOUS SPOT FILMS	NO																													
INFANT SKULL P.A.	NO	7.5	1/40-300		63	TO	67	KV.																						
INFANT SKULL LAT.					55	TO	60	KV.																						

Spine and Abdomen	B'KY	MA SEC.	SEC. AT MA	DIS.	cm. 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
CERVICAL SPINE LAT.	NO	50	1/10 -500	72	56	58	60	62	64	66	68																			
CERVICAL SPINE A.P.	Y'S																													
DORSAL LUMBAR PELVIC GIRDLE-A.P.	Y'S																													
PREGNANCY A.P.	Y'S	100	.5-200	36	48	50	52	54	56	58	60	62	64	66	68	70	72	75	78	81	84	86	88							
G.U. KIDNEY A.P. (RIBS B.D.)	Y'S																													
G.I. TRACT	Y'S																													
DORSAL SPINE LAT.	Y'S	100	.5-200	36											50	52	55	57	60	63	66	69	72	75	78	80	83	85		
LUMBAR SPINE LAT.	Y'S																													
PREGNANCY LAT.	Y'S	250	1¼-200	36											55	57	59	62	65	68	71	74	77	80	83	85	88	90		
PREGNANCY THOMS	Y'S																													
INFANT SPINE A.P.	NO	7.5	1/40 -300	39		63	TO	67	KV.																					

Special Views-Techniques	B'KY	MA SEC.	SEC. AT MA	DIS.	cm. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
NOSE A.P. VIEW																														
NOSE LATERAL	NO	10	.1-100	36		35	TO	40	KV.																					
MANDIBLE LATERAL-OBL.	NO	40	.4-100	cone		45	TO	55	KV.																					
CHEST and HEART A.P. "BUCKY"	Y'S	33	1/15-500	72		ADD 10 KV TO PA CHEST VOLTAGE																								
CHEST and HEART LAT. "BUCKY"	Y'S																													
KYMOGRAPH A.P.	K-M	-	100	30		TIME AND KV.P VARY WITH PULSE : SEE NOTES																								
KYMOGRAPH LAT.																														
RIBS ABOVE DIAPHRAGM - ON TABLE	Y'S	100	.5-200	36															44	46	48	51	53	55	57	59	61	64	66	70
INFANTS (FLASH TECHNIQUE)	NO	75	-300	39		50	TO	65	KV.																					
SOFT TISSUE TECHNIQUE (HIGH MA)	NO	300	3-100	39		28	TO	40	KV. SCREENS																					
SOFT TISSUE TECHNIQUE-CONVEN'L	NO	10	.1-100	39		USE EXTREMITY SCREEN TECHNIQUE DECREASING 7 TO 10 KV.																								
TEMPEROMANDIBULAR JOINT	Y'S	120	12-100	30		HEAD TABLE AND CYLINDER													53	55	57	59	61	63	64	66	68	70		
STERNUM- CARDBOARD	NO	60	6-100	CONTACT				55	TO	65	KVP.																			

1. The thickness of part should be measured along the line of the central ray. When an oblique view is made the measurements must be made obliquely also.
2. Accuracy in measurement is essential as small errors in Kv. will be greatly magnified in the final radiograph.
3. Make allowance for patients of extremely heavy musculature by increasing the exposure (usually more M.A.S.). When excessive thickness is a result of soft, flabby fat, decreased exposure is advisable (usually less Kv.).
4. Always immobilize the part as well as possible.
5. Cast work requires either twice the exposure in time or additional Kv. (usually 5 to 10).
6. To do soft tissue work, use 300 M.A.S. and corresponding low voltage or reduce conventional technique approximately 8 Kv.
7. Use a filter; possible exception at 72 inch distance.
8. The time to label a film is at the time of exposure.
9. Use smallest focal spot permissible.
10. CHILDREN: Extremities: Take other part for comparison.
    SMALL CHILDREN: (Under six years): Chest: Increase Kv. 2 to 5.
    INFANTS: Flash technique usually best.

INITIAL ANODE-FILM DISTANCE	FACTORS							
20"	1.0	1.6	2.3	3.2	4.0	5.8	9.0	13.0
25"	.64	1.0	1.4	2.1	2.6	3.7	5.8	8.3
30"	.44	.69	1.0	1.4	1.8	2.6	4.0	5.8
36"	.31	.48	.69	1.0	1.2	1.8	2.8	4.0
40"	.25	.39	.56	.81	1.0	1.4	2.3	3.2
48"	.17	.27	.39	.59	.69	1.0	1.6	2.3
60"	.11	.17	.25	.36	.44	.64	1.0	1.4
72"	.08	.12	.17	.25	.31	.44	.69	1.0
NEW ANODE-FILM DISTANCE	20"	25"	30"	36"	40"	48"	60"	72"

Westinghouse X-Ray Co., Inc., Long Island City, N. Y.

CALIBRATION CHART	LINE VOLTAGE OR POTENTIAL METER SETTING	MILLI-AMPERES	FILAMENT METER SETTINGS		
			TUBE No.	TUBE No.	TUBE No.
SCREENS					
FILMS					
LINE VOLTAGE					
DATE					

EXTREMITIES

A.P. P.A., LATERAL AND OBLIQUE

WITH SCREENS

SCALE	Ma. SECONDS				DISTANCE
	ADULTS	AGED	CHILDREN	INFANTS	
1	20	15	15	10	36

NON-SCREEN

SCALE	Ma. SECONDS				DISTANCE
	ADULTS	AGED	CHILDREN	INFANTS	
5	100	80	80	50	30

DENTAL EXPOSURES

RADIATIZED FILMS		
Ma. 30	Kv. 63	DIST. 18"
	UPPER	LOWER
INCISORS	4½	2½
CUSPIDS	3½	3½
BICUSPIDS	4½	4
MOLARS	6	4

SPEED FILMS		
Ma. 30	Kv. 63	DIST. 18"
	UPPER	LOWER
INCISORS	2½	1
CUSPIDS	2	1½
BICUSPIDS	2½	2
MOLARS	3½	2

TABLE C.

THICKNESS OF PART IN CENTIMETERS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
SCALE #1		35	36	37	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66
SCALE #2																			
SCALE #3										38	40	42	44	46	48	50	52	54	56
SCALE #4												47	49	51	53	55	57	59	61
SCALE #5	45	47	49	51	53	55	57	59	61	64	67	70	73	76					

THICKNESS OF PART IN CENTIMETERS	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
SCALE #1	68	70	72	75	78	81	84	87										
SCALE #2	51	53	55	58	61	64	67	70	73	76	79	82	85	89				
SCALE #3	58	60	62	65	68	71	74	77	80	83	86	89						
SCALE #4	63	65	67	70	73	76	79	82	85	88								
SCALE #5																		

908-A

Thickness of Part Radiographic Technique Chart

WITHOUT BUCKY: INFANTS: DISTANCE	INFANTS: Ma. SECONDS	INFANTS: SCALE	DISTANCE	Ma. SECONDS AGED & CHILDREN	Ma. SECONDS ADULTS	SCALE	PART WITH SCREEN	WITH BUCKY: DISTANCE	Ma. SECONDS AGED & CHILDREN	Ma. SECONDS ADULTS	SCALE
30	30	1	30	40	50	3	ATLAS & AXIS, A. P.	30	40	50	1
36	10	3	72	10	10	4	CHEST A. P. & P. A.	48	10	10	4
36	10	3	72	20	20	4	CHEST OBLIQUE	48	20	20	4
36	20	3	72	20	20	2	CHEST LATERAL	48	20	20	2
30	30	1	30	40	50	3	COLON, A. P. & P. A.	30	40	50	1
36	20	3	48	20	20	4	ESOPHAGUS, OBLIQ.	48	40	40	4
30	30	1	30	40	50	3	GALL BLADDER, P. A.	30	40	50	1
30	30	1	30	40	50	3	G. I. TRACT A. P. & P. A.	30	40	50	1
30	30	1	30	40	50	3	G. U. TRACT A. P.	30	40	50	1
30	50	1	30	60	75	3	HIP A. P. & P. A.	30	60	75	1
30	50	1	25	40	50	3	JAW LATERAL	30	60	75	1
30	30	1	30	40	50	3	KIDNEY, A. P.	30	40	50	1
27	50	1	27	60	75	3	MASTOIDS, LAT.	27	60	75	1
30	50	1	30	60	75	3	PELVIS, A. P. & P. A.	30	60	75	1
—	—	—	30	—	75	3	PREGNANCY, A. P.	30	—	75	1
—	—	—	30	—	75	3	PREGNANCY, LAT.	30	—	75	1
30	15	1	30	10	10	1	RIBS, ABOVE DIAPHRAGM A. P. & P. A.	30	25	30	1
30	50	1	30	60	75	3	RIBS, BELOW DIAPHRAGM A. P.	30	60	75	1
27	50	1	27	60	75	3	SINUSES, ETHMOID P. A.	27	60	75	1
27	30	1	27	40	50	3	SINUSES, FRONTAL P. A.	27	40	50	1
27	50	1	27	60	75	3	SINUSES, SPHENOID P. A.	27	60	75	1
27	50	1	27	60	75	3	SKULL, A. P. & P. A.	27	60	75	1
30	50	1	30	60	75	3	SKULL, LAT.	30	60	75	1
27	50	1	27	60	75	3	SKULL, BASE OF	27	60	75	1
30	30	1	30	40	50	3	SPINE, CERVICAL A. P.	30	40	50	1
36	45	1	72	75	100	1	SPINE, CERVICAL LAT.	48	75	100	1
30	60	1	30	75	100	3	SPINE, DORSAL A. P.	30	75	100	1
30	60	1	30	30	35	2	SPINE, DORSAL LAT.	30	75	100	2
30	60	1	30	75	100	3	SPINE, LUMBAR A. P.	30	75	100	1
30	60	1	30	75	100	2	SPINE, LUMBAR LAT.	30	200	250	2
30	30	1	30	40	50	3	STOMACH, P. A. OBLIQ.	30	40	50	1

FIXED KILOVOLTAGE TECHNIQUE CHART

DENTAL TECHNIQUE

65 K.V.P. 10 M.A. Distance - 12 inches.

	Regular Film		Speed Film	
	Upper	Lower	Upper	Lower
Incisors	8	6	6	5
Canines	7	7	6	6
Premolars	8	7	6	6
Molars	8	8	7	6

EXTREMITIES

65 K.V.P. 10 M.A. Distance - 30 inches.

PART	Non-screen	Screen
	Time	Time
Hand P.A. Obl.	1-1/2	1/8 *
Elbow P.A. Lat.	5	1/8
Foot A.P. Lat.	5	1/4
Ankle A.P.	7-1/2	3/8
Ankle Lat.	5-1/2	1/4
Knee A.P.	10	3/8
Knee Lat.	9	1/4

* Place Black Paper Under Film To Cover One Screen.

Chest 72 inch with Screens	Cm.	20	21	22	23	24	25	26	27
	Time	1	1-1/8	1-1/4	1-3/8	1-5/8	1-7/8	2-1/8	2-1/2

SKULL AND TRUNK

Distance - 30 inches. Screens

PART		Time
Skull	P.A.	3-1/2
Skull	Lat.	2
K.U.B. Lumbar Spine Dorsal Spine Pelvis G. I.	A.P.	1-1/2 to 2-1/2
*Lumbar Spine	Lat.	20 to 30 (cone)
Dorsal Spine	Lat.	3 to 6

* Distance May Be Reduced To 25 inches.

NOTE: On all thick parts use cone spot shots or Lysholm grid. In case of latter triple exposure time.

X-RAY DEPARTMENT, NATIONAL NAVAL MEDICAL CENTER.
RADIOGRAPHIC TECHNIQUE

Chest-Heart-Esophagus	B'KY	MA SEC.	SEC. AT MA	DIS.	cm. 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
CHEST and HEART P.A.	NO			72																										
CHEST and HEART OBL.	NO			72																										
CHEST and HEART LAT.	NO			72																										
RIBS ABOVE DIAPHRAGM	NO			72																										
ESOPHAGUS																														

Extremities	B'KY	MA SEC.	SEC. AT MA	DIS.	cm. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
SMALL PARTS - NON SCREEN	NO																													
SMALL PARTS - WITH SCREEN	NO																													
PARTS 10cm and over WITH SCREEN	Y'S																													
SPECIAL NON SCREEN FILM	NO																													
SPECIAL NON SCREEN FILM	Y'S																													

Head	B'KY	MA SEC.	SEC. AT MA	DIS.	cm. 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
SKULL	Y'S																													
SINUSES	Y'S																													
MASTOIDS	Y'S																													
SINUSES	NO																													
MASTOIDS and VARIOUS SPOT FILMS	NO																													

Spine and Abdomen	B'KY	MA SEC.	SEC. AT MA	DIS.	cm. 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
CERVICAL SPINE LAT.	NO			72																										
CERVICAL SPINE A.P.	Y'S																													
DORSAL LUMBAR PELVIC GIRDLE-A.P.	Y'S																													
PREGNANCY A.P.	Y'S																													
G.U. KIDNEY A.P. (RIBS B.D.)	Y'S																													
G.I. TRACT	Y'S																													
DORSAL SPINE LAT.	Y'S																													
LUMBAR SPINE LAT.	Y'S																													
PREGNANCY LAT.	Y'S																													
PREGNANCY THOMS	Y'S																													

Special Views-Techniques	B'KY	MA SEC.	SEC. AT MA	DIS.	cm. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
NOSE A.P. VIEW																														
NOSE LATERAL																														
MANDIBLE LATERAL-OBL.																														
CHEST and HEART A.P. "BUCKY"	Y'S																													
CHEST and HEART LAT. "BUCKY"	Y'S																													
KYMOGRAPH A.P.																														
KYMOGRAPH LAT.																														
RIBS ABOVE DIAPHRAGM - ON TABLE	Y'S																													
INFANTS (FLASH TECHNIQUE)				39																										
SOFT TISSUE TECHNIQUE (HIGH MA)	NO	300		39																										
SOFT TISSUE TECHNIQUE-CONVEN'L																														

1. The thickness of part should be measured along the line of the central ray. When an oblique view is made the measurements must be made obliquely also.
2. Accuracy in measurement is essential as small errors in Kv. will be greatly magnified in the final radiograph.
3. Make allowance for patients of extremely heavy musculature by increasing the exposure (usually more M.A.S.). When excessive thickness is a result of soft, flabby fat, decreased exposure is advisable (usually less Kv.).
4. Always immobilize the part as well as possible.
5. Cast work requires either twice the exposure in time or additional Kv. (usually 5 to 10).
6. To do soft tissue work, use 300 M.A.S. and corresponding low voltage or reduce conventional technique approximately 8 Kv.
7. Use a filter; possible exception at 72 inch distance.
8. The time to label a film is at the time of exposure.
9. Use smallest focal spot permissible.
10. CHILDREN: Extremities: Take other part for comparison.
    SMALL CHILDREN: (Under six years): Chest: Increase Kv. 2 to 5.
    INFANTS: Flash technique usually best.

INITIAL ANODE-FILM DISTANCE	FACTORS							
20"	1.0	1.6	2.3	3.2	4.0	5.8	9.0	13.0
25"	.64	1.0	1.4	2.1	2.6	3.7	5.8	8.3
30"	.44	.69	1.0	1.4	1.8	2.6	4.0	5.8
36"	.31	.48	.69	1.0	1.2	1.8	2.8	4.0
40"	.25	.39	.56	.81	1.0	1.4	2.3	3.2
48"	.17	.27	.39	.59	.69	1.0	1.6	2.3
60"	.11	.17	.25	.36	.44	.64	1.0	1.4
72"	.08	.12	.17	.25	.31	.44	.69	1.0
NEW ANODE-FILM DISTANCE	20"	25"	30"	36"	40"	48"	60"	72"

Varying degrees of tissue density may be cared for by further variation of M.A.S. or K.V.P.

Young children, or individuals suffering from emaciation or atrophy require less exposure. M.A.S may be reduced 25 to 50%; or K.V.P. may be reduced 3 to 8 or more.

An important exception to this is to be noted in the case of chest work. The lungs of infants and young children called for slightly more rather than less exposure. Accordingly no reduction of M.A.S should be made. Instead an increase of 3 or 4 K.V.P. may be found advantageous.

If the K.V.P. is low already very little drop is permissible. If the K.V P. is high a greater reduction is permissible.

People of markedly increased bulk require good judgement. When the increase is due to flabby tissue the K.V.P. called for by the caliper measurements may be somewhat high. It is best to be conservative in measurements and use about a 20% increase in M.A.S. When the increase in bulk is associated with heavy musculature and large bones, a further increase may be needed along with full K.V P. It may be well to apply the technique for lateral lumbar spine (less K.V.P. and much more M.A.S.) to A.P. views of certain huge types of individual. The use of compression bands and bags will often help.

Plaster casts require 8 - 10 K.V.P. increase or about doubled M.A.S.

Measurements that include the cast will usually indicate 5 or 6 K.V.P. more than the part itself. Thus if we add about 3 or 4 K.V.P. to that indicated by measurements including the cast we will come close to the optimal value. Screens aid in obtaining satisfactory contrast in cast work and close coning or diaphragming becomes more essential. Add another 6 - 8 K.V.P. for wet casts.

For soft tissue views of extremities a convenient method is simply to diminish K.V.P. by 8. Screens should be used to increase contrast.

Another method for soft tissue is to use 300 M A.S. at 39 inch distance with very low K.V.P. usually about 30. After some experimentation one should be able to gauge K.V.P. with nicety so as to obtain desired detail in either the skin and subcutaneous tissue or the muscles.

In the course of the next few years it is probable that photo-electric exposure meters, similar to those used in photography, will become available for general use.

The foregoing now brings us to the actual application of radiographic technique to patients and it is of value to review briefly the factors concerned and list some practical points.

RADIOGRAPHIC POINTERS AND PITFALLS

1. As a guiding rule remember that good results are lokked for - not excuses. Explanations seldom, if ever, quite explain.

2. Read the X-ray request slips carefully to determine as well as possible what views to take.

3. Perplexing cases will often have to be dealt with. It is then advisable to consult the roentgenologist. Otherwise you may obtain unsatisfactory views which will necessitate retakes with the usual attendant loss of time, waste of material, and general inconvenience.

4. Patients referred to X-ray are often ill, apprehensive or irritable. They should invariably be treated with kindness, courtesy and forebearance. Care is especially essential when there is pain; rough handling is never permissible. Remember that X-ray tables are not comfortable. Use ingenuity to provide support to injured parts and get adequate help in moving seriously injured or helpless cases. Be careful not to add to injury by careless manipulation. Do not remove dressings of any kind without permission.

5. In dealing with female patients do not forget such matters as sheets for draping and avoid any unnecessary exposure. Be sure to have a nurse or other woman attendant present. Do not forget to have these patients instructed as to removal of hair pins, girdles, corsets, and silk or rayon undergarments as may be necessary.

6. In skull work inquire as to dentures; removal may be necessary.

7. Be sure and precise in your movements and instructions. Work systematically and quietly. Such will instill confidence and aid in obtaining good cooperation from your patient.

8. Adjust controls and get everything possible ready before you position the patient. Otherwise you may be guilty of leaving someone in an awkward, uncomfortable and even painful position for an unduly long time while you fuss with the various controls, peer at charts, go after films, get identification markers ready, etc. This is especially essential when views are to be taken of ill patients in the upright position.

9. Never smoke in the radiographic room while working on patients. Such is obnoxious.

10. Do not attempt to interpret films or discuss such with the patient.

11. Remember that when you share in the professional knowledge pertaining to a case, such knowledge is not yours to broadcast. Loose tongues are not permissible and may cause much harm.

12. Whenever possible out-patients should remain in the department until their films have been inspected. Additional views or retakes may be required.

13. In cases of injured out-patients find out if they are to be seen by a medical officer, before they leave, and take appropriate action.

14. To minimize exposure of patient to the softer rays which experience has shown are most dangerous to the skin, see that a 1 mm. filter of aluminum is in place except possibly in the case of 6ft. chest plates. Oil immersed tubes nearly always have the equivalent of 1/2 mm. aluminum filtration so that addition of a 1/2 mm. aluminum-filter will suffice. When using the older type non-shock-proof machines never forget precautions as to electrical hazards.

15. Keep account of the amount of exposure in cases subjected to frequent radiation, bearing in mind safe tolerances.

16. Minimize personal exposure.

17. When dealing with extremities of children and young adolescents always take both sides. The unaffected side provides a means of comparison.

18. When young children are difficult to manage, it may sometimes be well to propose that a nurse or other attendant manage the child while the relatives wait elsewhere.

19. In using any method it is not sufficient to follow charts blindly. The bulk of one subject may be largely bone and muscle; that of another may be soft fat. In the first instance there will be considerably more resistance to the passage of X-ray and more voltage or more milliampere seconds will be required. Again a large abdomen may be due to gaseous distention and the routine exposure based on its size will be too great. The chests of infants will require more exposure to get adequate lung detail than would ordinarily be estimated. Children otherwise take less exposure; the aged likewise.

20. When taking oblique views it is to be remembered that the thickness of tissue to be penetrated will often be different than the A.P. or lateral dimensions. Measure along the path of the central ray. Further, if the X-ray tube is tilted, rays are spread over a greater plate area and some increase in exposure may be necessary.

21. When small cones, disphragms or extension cylinders are used slightly more exposure will be needed. (The amount of increased exposure can be marked on the cone itself or embodied in the exposure chart).

22. When using a variable kilovoltage scale, close accuracy is essential because small variations cause disproportionately large effects on radiographic density.

23. Screen speeds vary and accordingly it is necessary to know what type of screens are being used. High speed screens usually permit a drop of 20 to 25% in time or 3 - 4 K.V.P. in penetration.

24. If special non-screen films are used in the department, care must be taken to prevent any mixing with regular film.

25. Films from various manufacturers may vary in speed. If you change to a

different brand, make tests to ascertain if your exposure factors will need adjustment.

26. It is necessary also to bear in mind the type of detail desired and the pathology involved in certain cases. In some instances visualization of the periarticular structures may be desired rather than bone detail. Less exposure will then be in order. At times two views of different density will be desired. Again in cases of chronic bone infection there is often a great increase in bone density. Additional views with increased exposure are then advisable.

27. Avoid extravagance in films. They are quite expensive.

28. The habit of using cones is a good one to cultivate.

29. Identification of films is usually accomplished by lead numbers mounted in a suitable frame. The importance of correctness can hardly be overemphasized. Mistakes at best lead to annoying confusion and loss of time. At worst they may fasten a serious diagnosis on the wrong patient, a situation fraught with dangerous possibilities. The correct placing of the markers for right and left is also of great importance, a thing which the younger worker seldom realizes until a mistake finally results in some unpleasant consequence.

With cystoscopic X-ray tables, since patients almost invariably are placed in the supine position, it is good practice to mount an "R" or "L" under the table top so that it will show in the corner of every film made. To avoid "burning" through markers when heavy exposures are made, the marker should be placed under part of the body or else should be provided with a strip of thin copper.

Include place and date on markers.

30. Make a habit of inspecting all your work with a critical eye.

31. Record exposure data of each case and do not rely on your memory. It is well to prepare and file a technique card on each case.

No.__________ U.S. Naval Hospital,__________ Ward__________

Name__________ Rate__________ Doctor__________

Age______ Height______ Weight______

date	part	part thick	KV	MA	Time	Dist.	Ray Direct	Machine	Screens	B'ky.	Size & No. of films	Remarks

RADIOLOGIST__________

TECHNICIAN__________

32. Bear in mind the capacity of your tubes. It is a good plan to post capacity charts in the control booth. Do not leave filament lit longer than necessary, especially on high settings.

33. Be sure all work is properly authorized.

34. Don't leave exposed films in the Bucky tray. Sooner or later a double exposure will result.

35. Use plain film holders and cassettes in regular rotation. Otherwise some films will go unused too long with resultant deterioration.

36. Remember that very little stray or secondary radiation will fog films. They must be kept in a safe place.

37. If the hinged ends of the cassettes are always placed the same way relative to the patients - hinges to head and flaps to feet - the films can always be placed in the hangers right side up to facilitate inspection. Without regular system a number of films will always be upside down in the hangers.

38. When taking several views on one film, avoid rotating the film. Otherwise study of the radiograph will require constant turning about of the film.

39. Keep unessential people out of the way when you are at work. You can't afford distraction.

40. Make good use of sand bags and compression devices to obtain support and immobilization.

41. Stationary grids should be kept flat and protected from moisture. Do not abuse by rough handling.

QUESTIONS:

1. What is meant by the following abbreviations? MA., MAS., KVP., MFD.

2. What is the effect of milliamperage on radiographic density?

3. State the law of the inverse square and give its application to radiography.

4. What is the effect of KVP on radiographic density; on penetration; on soft tissue differentiation; on time of exposure?

5. Discuss application of screens to radiography.

6. What is secondary radiation and why is it important to eliminate it from radiographs?

7. Name methods in general use to diminish secondary radiation.

8. Describe the Bucky diaphragm.

9. At what thickness of part does secondary radiation become troublesome?

10. What is the effect of anode film distance on distortion? ; of object film distance?

11. State principal factors affecting definition; contrast; density; distortion.

12. What are the advantages and disadvantages of special non-screen films? How do they differ as to developing time? Should they be used with intensifying screens? Why?

13. State suitable MAS for the following:
- (a) Non-screen extremity work with regular film.
- (b) Double screen extremity work.
- (c) Lumbar spine with double screens and bucky both for AP and lateral projections.
- (d) Sinuses and mastoids with double screens and using extension cone; no bucky.
- (e) Six-foot chest films.

14. How should exposure value be altered for radiography of children? ; of very robust adults; of the aged?

15. What is the importance of a filter?

16. How would you determine a satisfactory kilovoltage scale for thickness of part technique?

17. Name ten essential points in the conduct of work in a radiographic room.

18. By reference to standard technique chart and screen speed chart, convert technique for 12 cm. part, cardboard, to screens.

POSITIONING

UPPER EXTREMITY.

<u>Hand:</u>

Conventional views:

These usually include a dorso-ventral and an oblique projection. For the first, place the hand palm down on the film and center over the upper row of joints (meta-carpo-phalangeal). In taking the oblique view, the object is to separate the fingers to avoid confusing superimposition. To spread the fingers a convenient support may be provided by a series of wooden tongue depressors separated by corks. The other hand may be used to steady the one being radiographed. A sandbag placed over the forearm may be needed.

Additional views:

A series of views of an individual finger made at a variety of angles is often desirable particularly in injuries about the joint. The larger dental films may answer the purpose here.

True lateral views of the hand may be called for.

When the thumb is concerned it should be the practice to take an additional view with the forearm resting on the table with radial (thumb) aspect down, the hand thus resting on the lateral portion of the index finger and the base of the thumb.

Wrist:

Conventional views:

These include the dorso-ventral and true lateral. The first should always be taken with the hand deviated outward toward the ulnar aspect (little finger). This brings the navicular or scaphoid into better relief and renders the detection of fractures of this bone more certain.

Additional views:

When ulnar deviation is not possible due to pain or stiffness, additional views are necessary; try one or more of the following:

1. Center tube just beyond the finger tips and then angle it so that the central ray passes through the wrist.

2. Place a pad of gauze or other convenient material under the palm so as to tilt the hand upward at an angle of about 20 degrees.

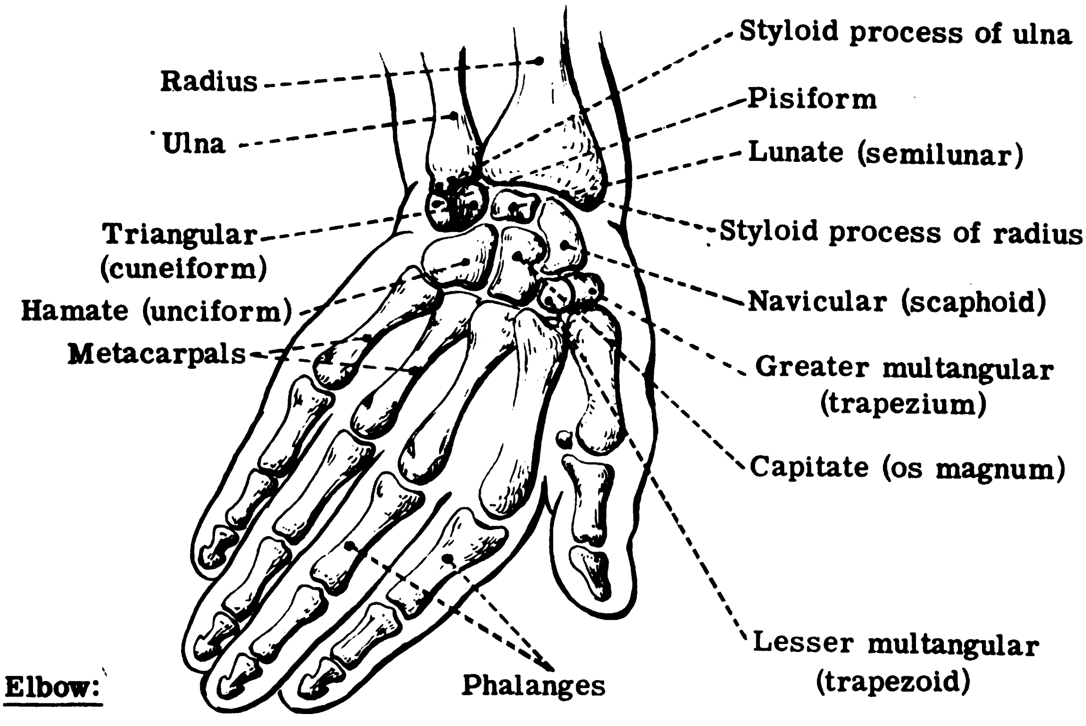
3. Place hand in oblique position.

When taking lateral views in case of fractures of the lower end of the radius it is important that the wrist does not deviate from the true lateral. This view when accurate is what tells the surgeon whether or not reduction is satisfactory. An additional lateral view with the radius next to the plate may be desired.

Forearm:

Conventional views:

These include the ventro-dorsal and true lateral, and should include wrist and elbow. In the first remember that the palm should be up. Remember that in all cases a sand bag properly placed will help immobilize and steady the part.



Elbow:

Conventional views:

These include the ventro-dorsal and true lateral. The patient should be seated on a low stool so that it will be easy to rest the entire arm on the table. Once more in the first view the palm should be up. In the lateral views the elbow should be flexed at a 45 to 90 degree angle and the hand should be in a lateral position. If it is turned palm down the head of the radius will be rotated so that its resultant projection will be practically the same as in the ventro-dorsal view.

Additional views:

When the elbow cannot be straightened the usual ventro-dorsal view becomes impracticable. It is then best to take two views, one with the forearm in contact with the plate, the other with the upper arm in contact.

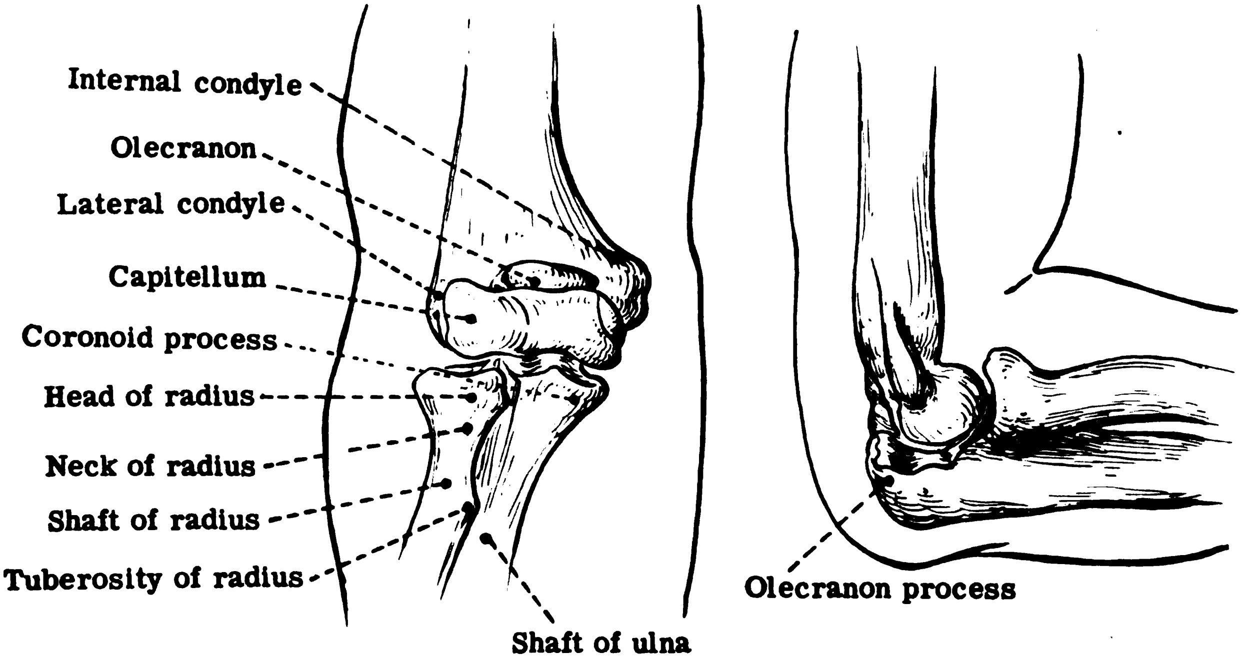
When the elbow cannot be straightened from acute flexion it is also best to take a view with the upper arm resting flat on the plate in antero-posterior position and the central ray directed through the humerus about an inch above the elbow joint.

Humerus:

This is best radiographed with the patient supine. A view is taken with the humerus in external rotation and a second with the arm in internal rotation. The lower end of the plate should extend below the elbow.

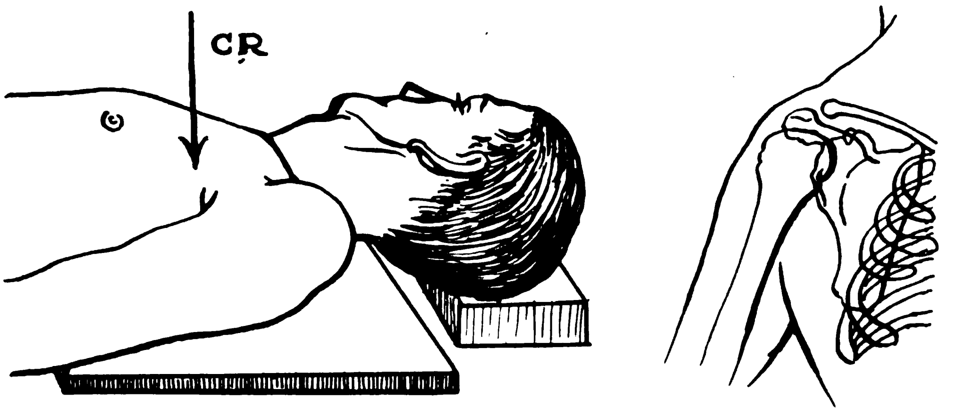
When rotation is impossible a plate can be placed between arm and body to obtain a lateral projection.

Stereoscopic films may also be of advantage. It might also be noted that in case of injury to the upper end of the humerus, shoulder technique should be employed as the humeral head forms part of that joint.



Shoulder:

The shoulder commonly exceeds 10 cm. in thickness and accordingly it is usually best to employ the Bucky diaphragm or pay special attention to use of cones or diaphragms. The wafer grid may also come in handy.



A. P. SHOULDER

Conventional views:

The patient lies on the back and the upper border of the cassette should extend several inches above the highest point of the shoulder, the lateral plate border should extend several inches beyond the point of the shoulder. If damage to the clavicle is suspected the plate should be large enough so that this structure is included. (11 x 14 transversely). The patient should cease breathing during the exposure. The central ray should pass through the middle of the scapula.

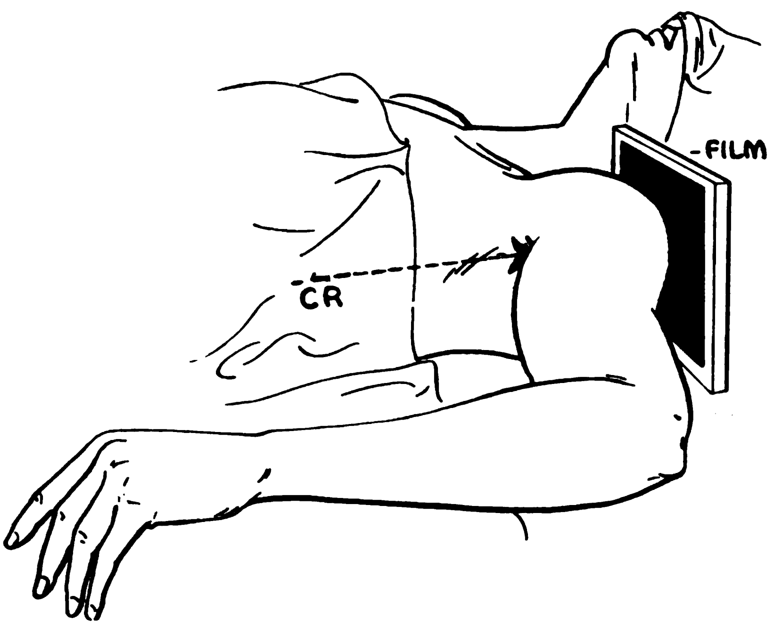
Views in both external and internal rotation are recommended and stereoscopic views are frequently called for.

Additional views:

An upright lateral view is often made with the patient postured in whichever anterior oblique position is required, rotation being about 45 degrees. A vertical Bucky or sharp coning will naturally help.

Axial views:

These are often required in exposures about the shoulder joint. Cones or diaphragms are in order as the Bucky cannot be used. The small portable units are best adapted for this type work.



AXIAL VIEW, SHOULDER

They may be made either with the plate in the axilla or above the shoulder. In the former case, the patient should sit with the humerus extended over the end of the plate as far as possible. The tube is given a 20 degree tilt to direct the ray laterally in the direction of the elbow.

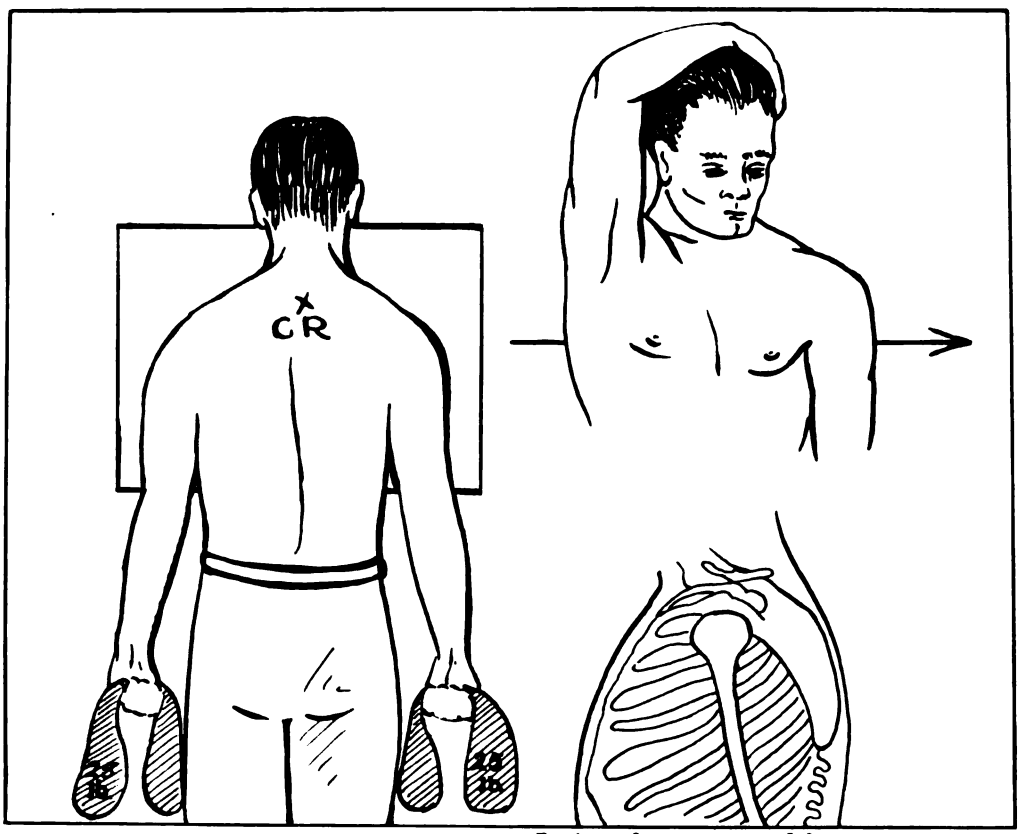
The other view can best be made with the patient supine and the humerus at right angles to the body. The plate is placed on edge above the shoulder. A shock proof tube head is placed so that its central ray is perpendicular to the plate, parallel to the table and passes through the head of the humerus.

Clavicle:

This bone is readily included in conventional views of the shoulder. However, the P.A. position is preferred. Conventional chest films often show the clavicle very well.

To demonstrate acromio-clavicular separation, views should be made with the patient upright and holding equal weights in each hand. This will bring out any separation and, if desired, comparison with the uninjured side can be readily obtained.

An additional view of the clavicle is sometimes made with the tube angled toward the feet 30 degrees.



Acromio-clavicular joints Lateral upper end humerus

Scapula:

Conventional views:

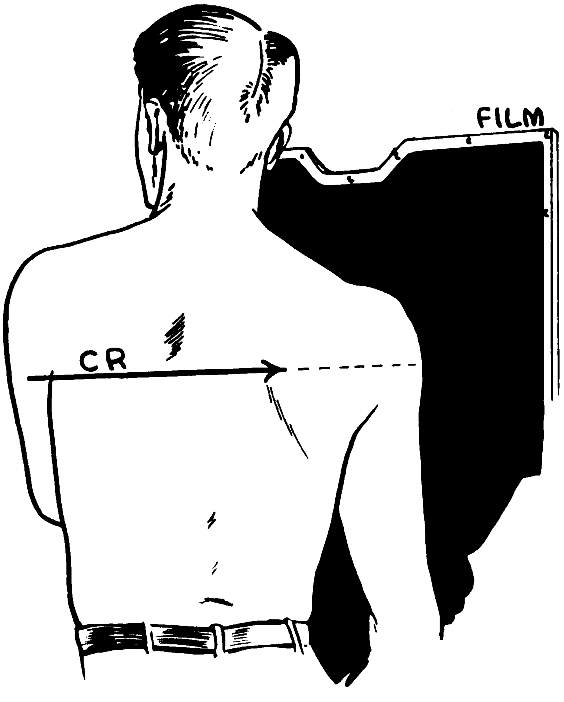
These include A.P. and lateral projection.

A.P.:

This is best taken with the arm above the head as this tends to bring the scapula out from behind the chest. The patient is supine.

Lateral:

The patient stands obliquely in front of the cassette with the injured shoulder in contact and the hand palm outward in the back. The hand on the uninjured side is placed on the head.



LATERAL SCAPULA

LOWER EXTREMITIES.

Foot:

Conventional views:

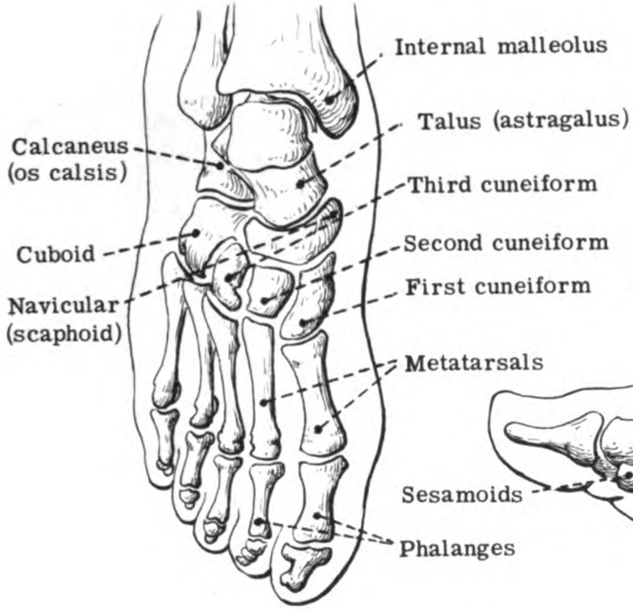
These include dorso-ventral, lateral and oblique projections.

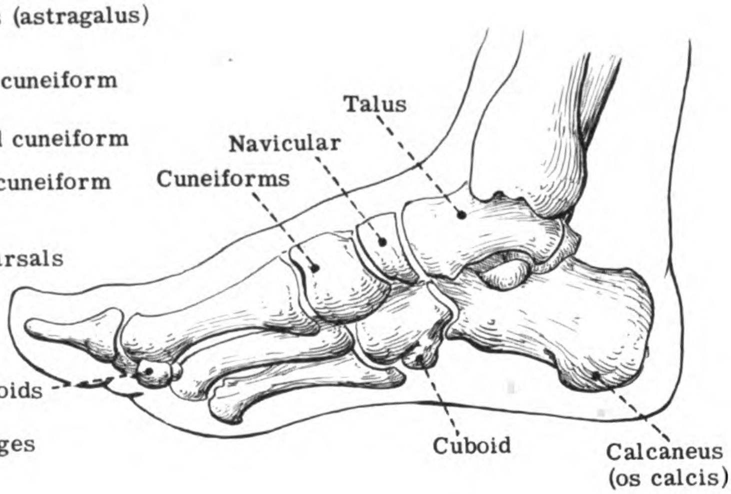
In the first the patient sets on the table with sole of the foot resting on the plate. The central ray usually passes through the distal ends of the metatarsals and is usually perpendicular. However, the site of injury may modify this: likewise the degree of exposure. If clear views of both phalanges and tarsal bones are needed,

two exposures should be made. In the case of the tarsal bones a 15 degree tilt of the tube toward the head may help.

For the lateral view the patient lies on the side with the outer edge of the foot down. There should be no eversion or inversion.

The oblique view is always needed in case of injuries to the metatarsals and phalanges and also the more anterior tarsals.





An oblique can be made by having the patient on his side as for the lateral view. The foot, however, is then turned so that the sole faces upward as much as possible.

The best method is to have the patient ~~be~~ face down with the dorsal aspect of the foot on the plate. The foot is then rotated outward about 25 degrees.

The central ray is perpendicular in both cases.

Additional views:

Axial view of the os-calcis. This is needed in fractures of this bone. The patient lies face down with the heel resting against the plate, which of course is placed perpendicular to the table. The tube is angled downward from the horizontal about 35 degrees and the central ray is directed through the middle of the os-calcis.

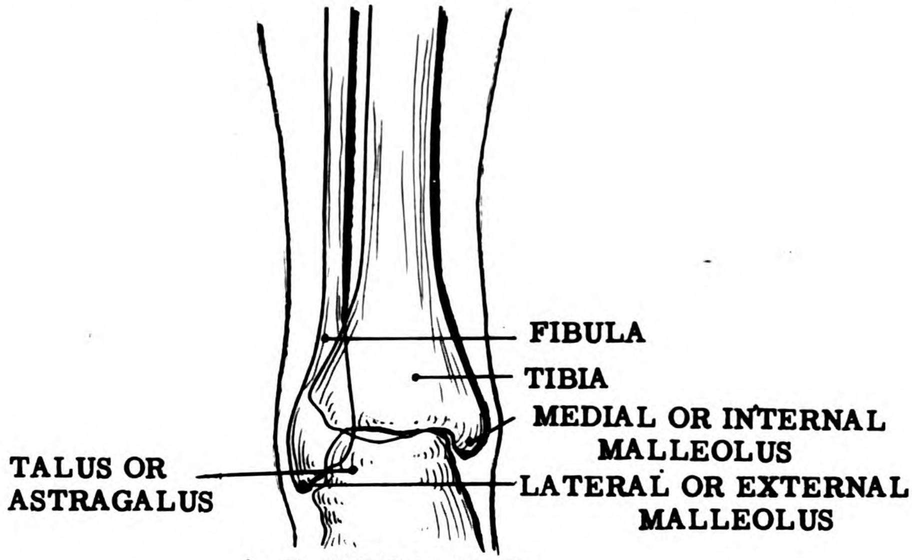
Ankle:

Conventional views:

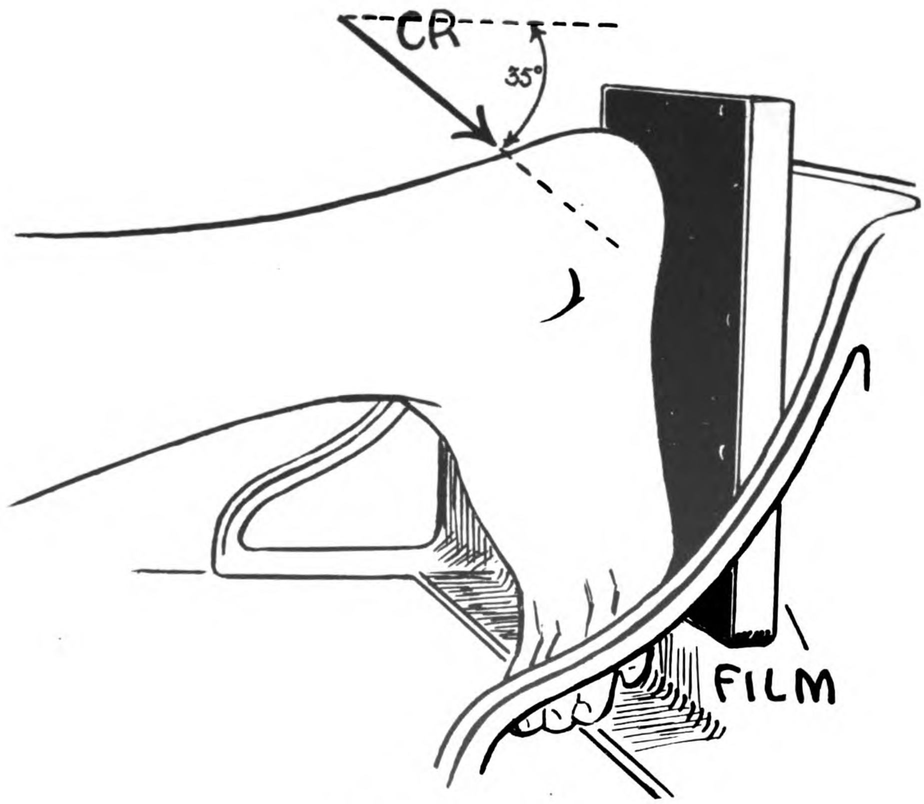
These include antero-posterior and lateral projections. The central ray is

perpendicular and passes through the lower end of the tibia.

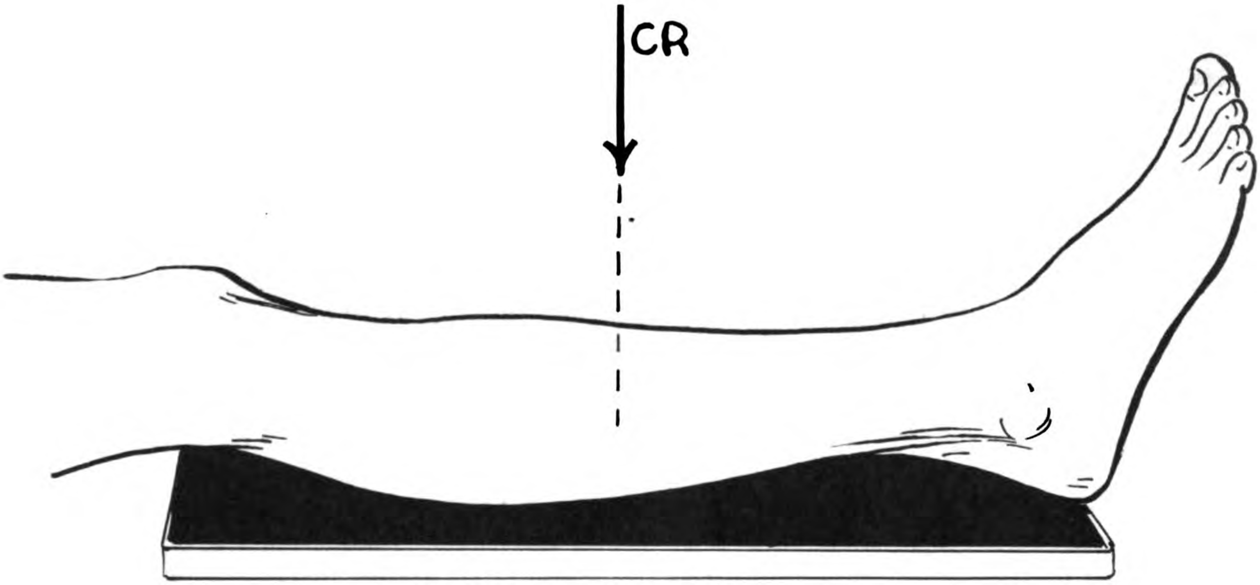
When ankle views are called for it is often well to include one or more of the foot.



A. P. ANKLE JOINT



AXIAL VIEW, OS CALCIS

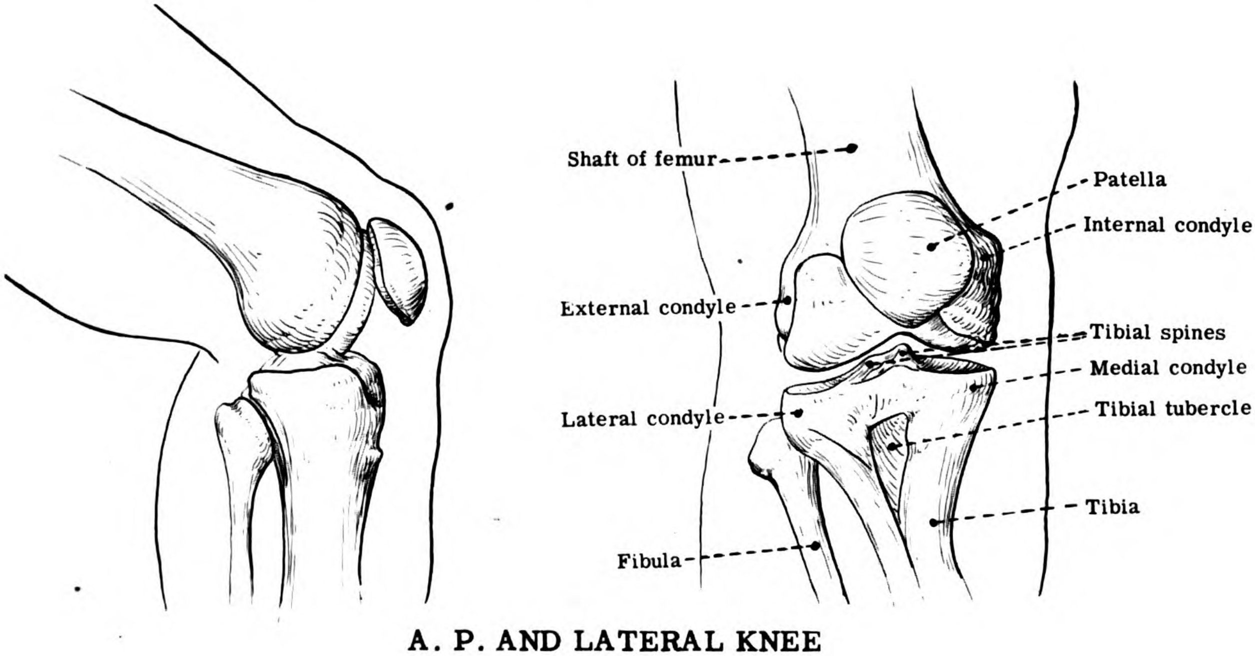


A. P. LOWER LEG

<u>Tibia and Fibula:</u>

Conventional views:

These include antero-posterior and lateral. The entire length should be included. It is to be remembered that a fracture in the lower portion is often accompanied by one near the knee (usually the fibular neck).



A. P. AND LATERAL KNEE

Knee:

Conventional views:

These include antero-posterior and lateral projections.

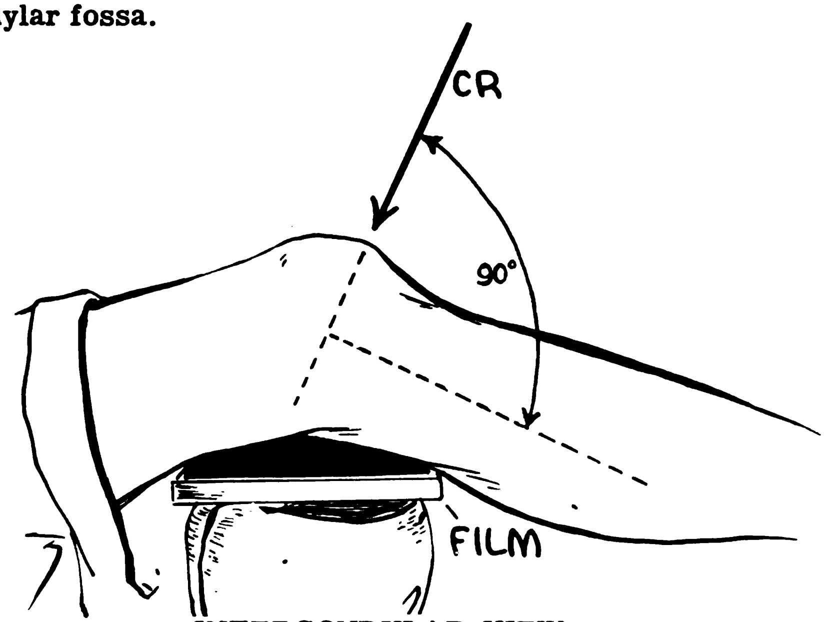
For the first the patient usually lies on his back with the patella over the center of the plate. The Bucky diaphragm is usually advisable. The central ray passes through the lower margin of the patella and is commonly perpendicular. However, a 10 to 15 degree tilt toward the head is better.

A postero-anterior projection will also answer well and may be easier managed when the knee cannot be completely straightened.

For the lateral view the patient lies on the affected side and the knee is slightly flexed. The uppermost limb is flexed at both knee and hip and brought well forward of the knee to be radiographed. A sand bag placed under the uppermost limb will be helpful to prevent rotation of the patient toward the prone position. The central ray is perpendicular and passes through the joint.

Additional views:

Intercondylar fossa.

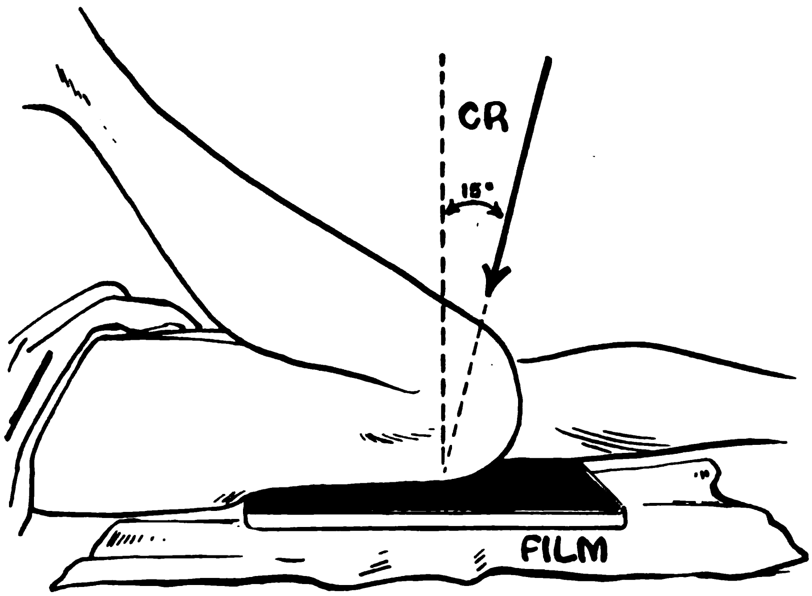


INTERCONDYLAR VIEW

The patient lies on his back with the knee slightly flexed. A small 5 x 7 cassette is placed under the knee and supported by a sandbag of about 4 inch thickness. The tube is tilted so that the central ray is perpendicular to the tibia (long axis) and passes through the joint space. A small cone or extension cylinder should be used. A curved cassette or curved cardboard holder will be convenient.

Axial view of patella.

The patient is placed face down with the knee in acute flexion and the lower plate border several inches below the knee. The tube is tilted toward the head about 15 degrees and the central ray passes through the patella. Don't forget the cone.



AXIAL VIEW, PATELLA

Femur and Hip:

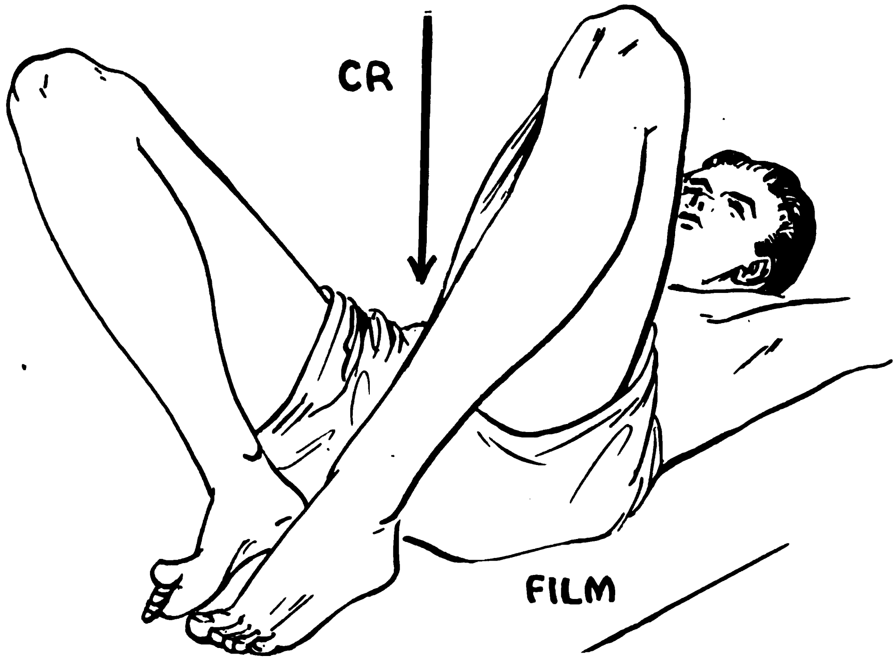
Conventional views:

These include A.P. and lateral views of the lower end and most of the femoral shaft and A.P. views of the upper part of the shaft including head and neck. For good coverage the large 14 x 17 films are needed, at least for the first views taken. The Bucky or Wafer Grid should be used.

Additional views:

These are needed chiefly in cases of fracture of the neck.

1. A very simple and valuable view for lateral aspect of both femoral necks is made simply by positioning the patient supine with both knees drawn well up and the thighs abducted. A 14 x 17 cassette (in the Bucky) is placed transversely to include both hips and the tube is centered on the midline and tilted toward the head so that the central ray is parallel to the femoral axes and enters the body at the symphysis pubis.



LATERAL VIEW OF BOTH FEMORAL NECKS

2. (a) If the patient can lie on the injured side, another view to produce a lateral projection of the neck can be obtained by rotating the patient slightly toward the back and bringing the upper (uninjured) leg posteriorly. The tube is centered over the femoral neck. Support should be furnished the upper leg.

(b) Again the patient may be in true lateral position with the upper thigh acutely flexed. The tube is angled about 25 degrees toward the head and the central ray passes through the neck.

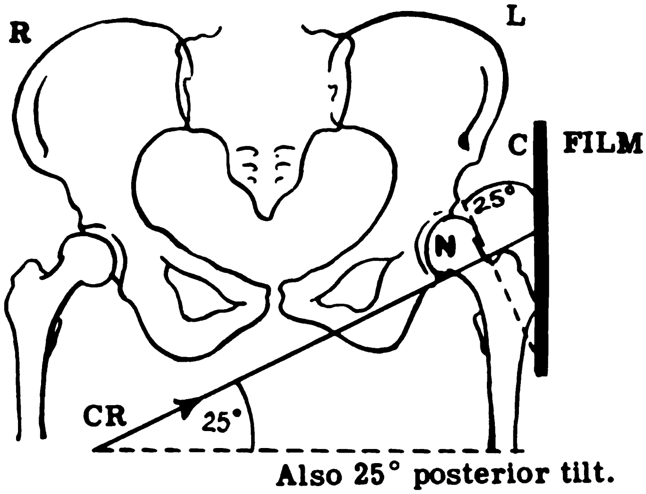
3. When the patient must remain supine, angle views using cones or extension cylinders are needed.

(a) A cassette (8 x 10) is placed upright against the injured hip with its center over the trochanter, and its upper edge tilted outward to produce a lateral inclination of 25 degrees. The X-ray beam is directed across from the opposite side with a downward tilt of 25 degrees and a tilt toward the head, from the true lateral of 25 degrees.

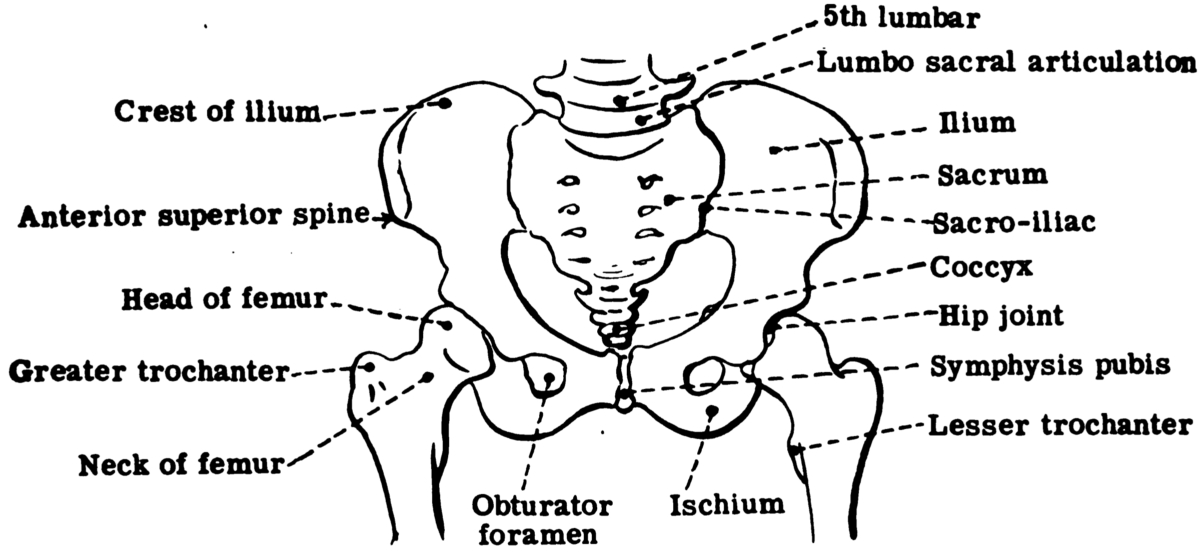
(b) If the thigh on the uninjured side can be flexed on the abdomen a cassette may be placed in the same position except that the tilt is omitted, and the X-ray beam directed through the neck horizontally (since the uninjured leg is out of the way). The 25 degree angle toward the head is retained.

Cylinders, cones, or wafer grids are essential to good work.

4. Finally in many cases of injury to the hip a good set of stereos is much to be desired.



LATERAL VIEW OF FEMORAL NECK

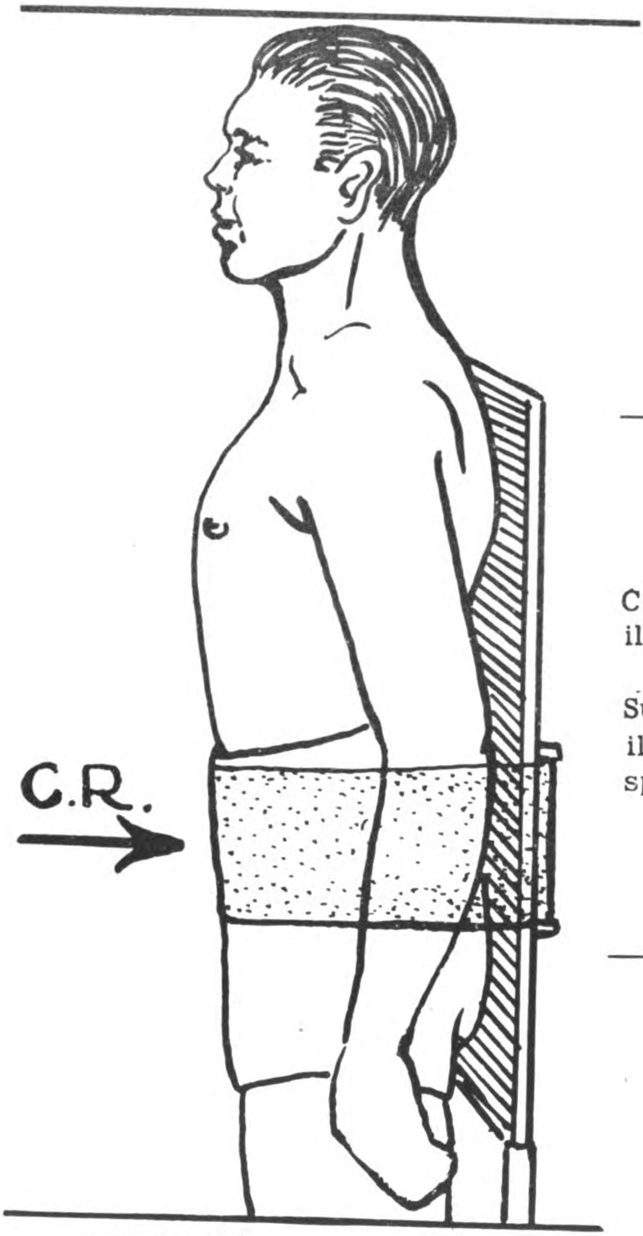


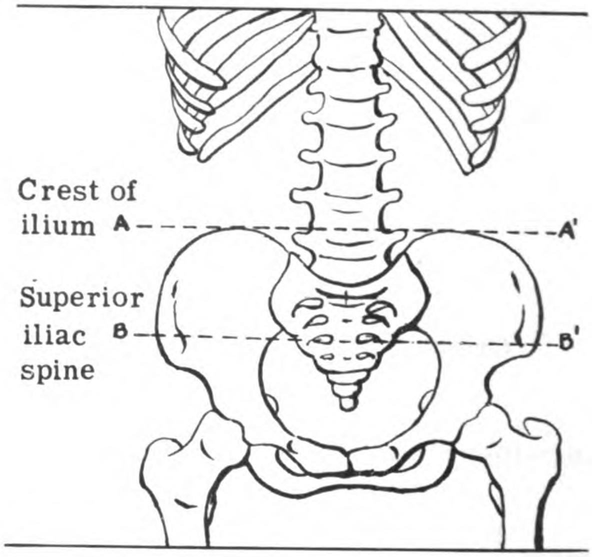
PELVIC GIRDLE

<u>Pelvis:</u>

Conventional:

The A.P. projection generally answers and stereoscopic views are an aid in visualizing deformities from fracture. The legs should be well straightened and the feet brought close together. Reduction in exposure factors may be necessary to bring out detail in the iliac crests. Place 14 x 17 cassette transversely with upper edge just above the iliac crests.





Additional:

Standing views may be desired to determine pelvic tilt. Be sure, when taking such views, that the patient is standing straight preferably in bare or stocking feet. Use 14 x 17 films with Bucky.

Additional views:

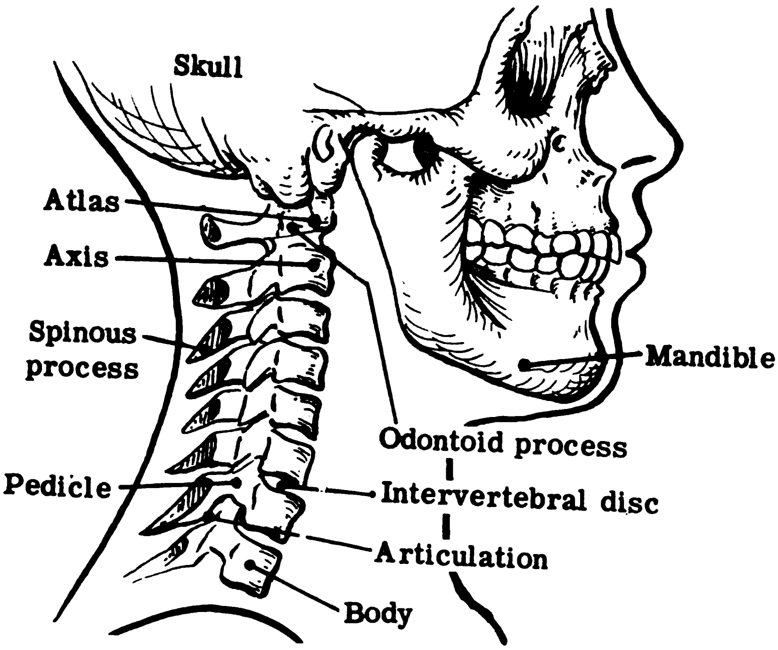
1. A lateral view for the ilium may be desired. For this, the patient lies face down with uninjured side elevated so that the pelvis is rotated 45 degrees. The injured side should,of course,be in the center.

2. Axial view of Pubic Arch.

The patient sits on the table and leans back 45 degrees. A 10 x 12 cassette will answer and the lower edge should be several inches below the symphysis.

3. Pelvis for prostate.

The patient is supine and the tube tilted toward the feet 20 degrees. Its central ray should hit the body at the level of the ant. sup. spine of the ilium.



Spine:

Cervical Spine:

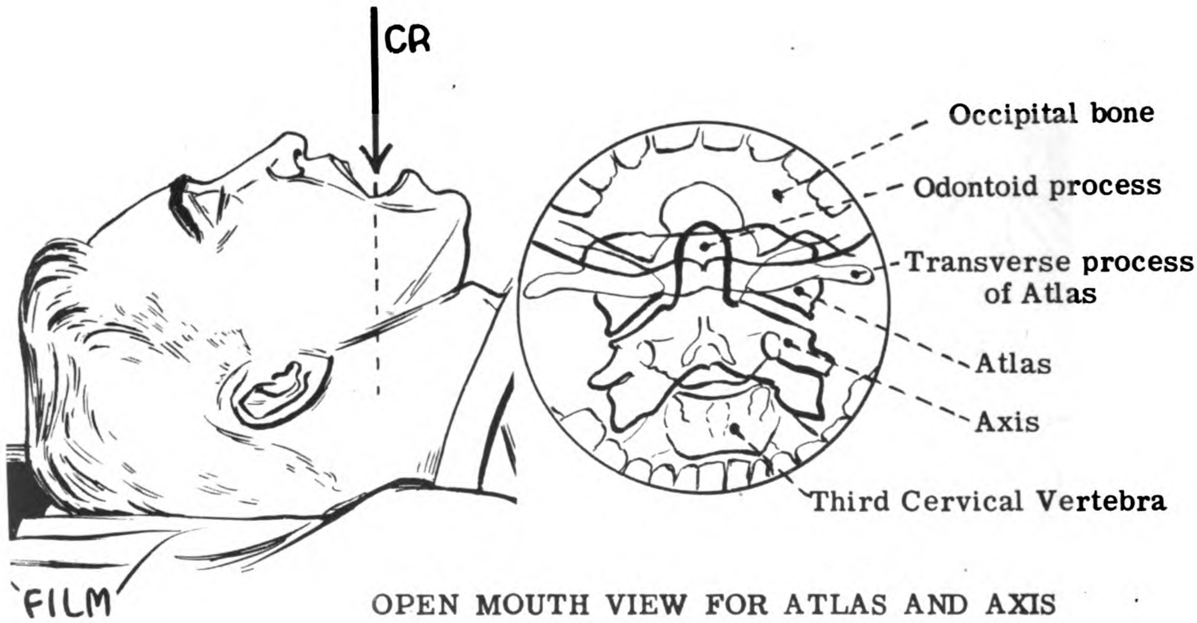
Routine views include A.P. and lateral. For the A.P. view the patient lies on his back on the Bucky table with the head tilted a trifle back. The cassette (8 x 10) should extend above the occiput and the tube is angled upward toward the head about 5 degrees. The beam is centered on the 4th segment. Breathing should cease during exposure.

For the lateral views the patient sits on a stool with the side of the head parallel with the cassette, which usually is placed in the vertical plate changer used for chests. A small cardboard box or piece of balsa wood can be placed between the head and the plate changer to afford support and prevent motion. The shoulders are allowed to droop as much as possible and the one nearest the tube brought back an inch or so. The X-ray beam is perpendicular to the plate and centered on the 3rd segment.

If the patient cannot sit up a plate may be placed against the head with the lower edge firmly against the shoulder; or it may be placed with its surface against the shoulder. The lower two vertebrae are apt to be missed in such views.

Larynx:

This lateral cervical view also shows the larynx quite well. K.V.P. should be lowered if this structure is to be the main object of the view.



OPEN MOUTH VIEW FOR ATLAS AND AXIS

Additional views:

1. Special View of the Atlas and Axis.

The patient lies on his back with the chin slightly elevated and the mouth wide open. A 5 x 7 or 8 x 10 cassette is used with its center under the mouth, the edge reaching the occipital protuberance. Central ray vertical through mouth.

2. Oblique views.

These may be made in either anterior or posterior positions, the latter being more convenient. For the anterior oblique the patient is placed in prone position and the body rotated about 45 degrees, the head, however, being about 25 degrees from true lateral.

In the posterior oblique view body and neck are rotated 45 degrees.

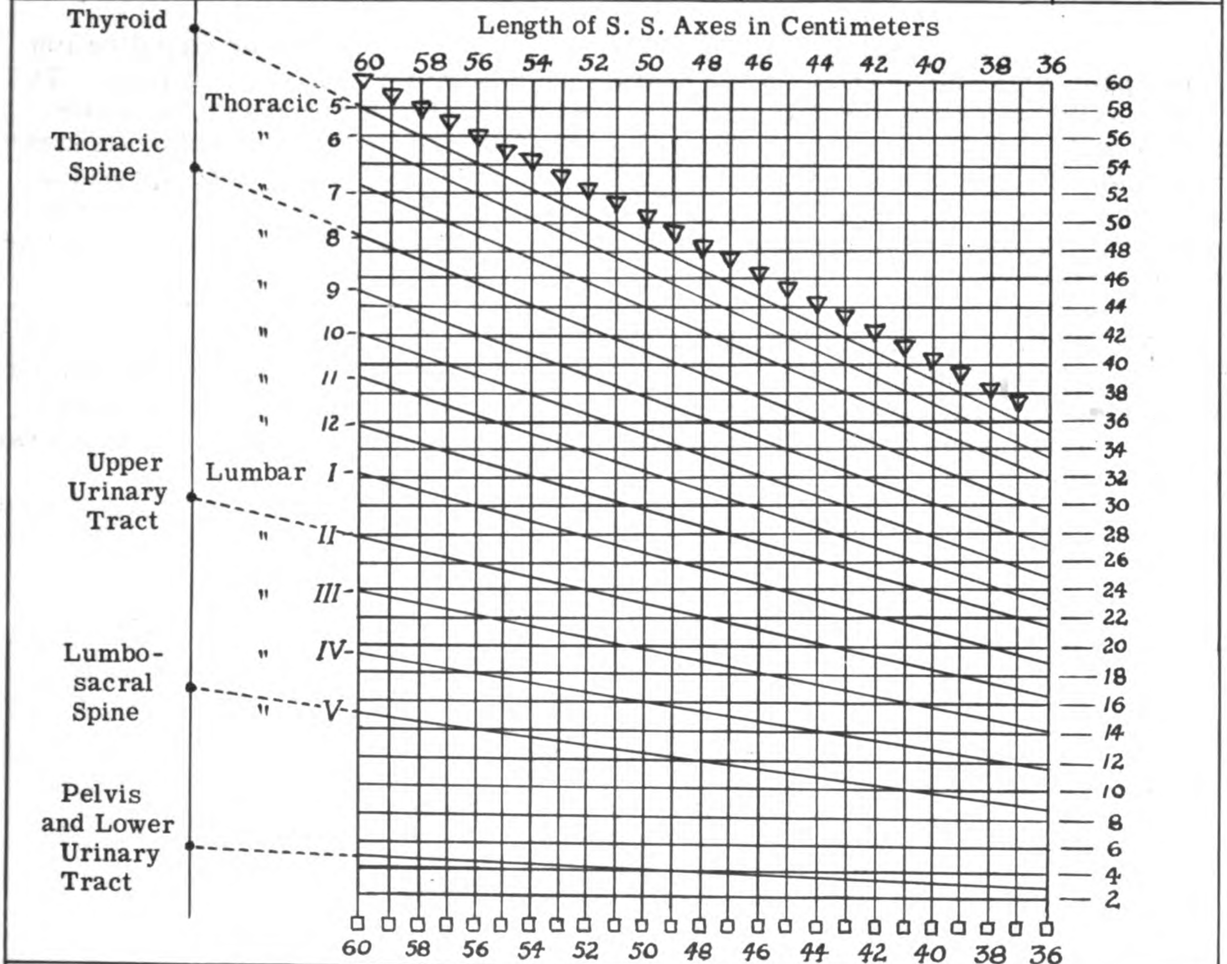
The X-ray beam is perpendicular.

Dorsal Spine:

Conventional views include A.P. and Lateral projections.

For the first the patient is placed in supine position on the Bucky table with a

Center Points for Certain Routine X-Ray Examinations	Location of Vertebral Bodies Relative to Sternal Notch and Pubic Symphysis	GRAPH FOR LOCATING VERTEBRAL BODIES IN SUBJECTS OF VARYING HEIGHT	Centimeters above Pubic Symphysis



▽ Represents Suprasternal Notch at Upper End of S. S. Axis

□ Represents Upper Surface of Symphysis Pubis at Lower End of S. S. Axis
In Subjects with Axes varying from 36 cm. to 60 cm.

S. S. Axis = distance from symphysis to suprasternal notch.

14 x 17 film extending to the lower cervical region. The X-ray is centered over the mid dorsal region (6th segment best). The breath is held during exposure.

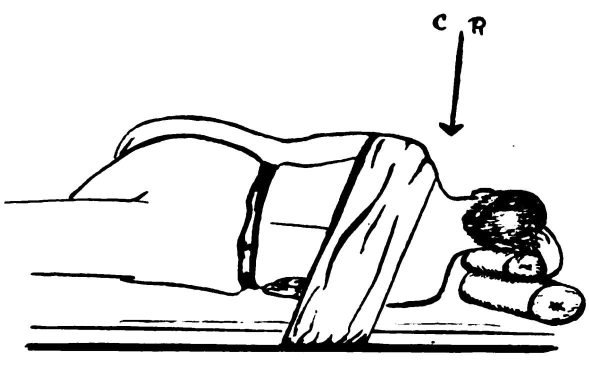
The lateral view is usually made with the patient on his side with both arms extended over the head. However, the best views are obtained with the patient upright as for the lateral chest view. More exposure is needed and the fast chest Bucky or a Lysholm grid will greatly improve the results. Either 48 inch or 72 inch distance may be used. Both forearms should rest on the head.

Oblique views are occasionally desired and are easily obtained by rotating the patient 45 degrees from the supine position.

Lateral view of upper dorsal vertebrae:

The conventional lateral view of the dorsal spine produces poor visualization of the upper segments because of the heavy shadows from the shoulder girdles. To overcome this difficulty the patient is postured on the desired side with the under arm above the head and the shoulders rounded. The uppermost arm rests extended on the side of the body with the upper shoulder as low as possible. A compression band arranged over the shoulder so as to have a caudal pull, will aid. To keep the spine parallel to the table the head should be supported and a folded sheet placed under the lumbar region.

The central ray should ordinarily be directed vertically through the region of the third dorsal. When the shoulders show reduced mobility, the tube may be angled toward the feet (caudad) about 5 degrees. Exposure factors approach those of the lateral lumbar spine: 200 M.A.S. at 70 Kv.P. appears an average,employing of course, the grid.



LATERAL VIEW, UPPER DORSAL VERTEBRAE

Lumbar spine:

Conventional views include the A.P. and lateral. For the A.P. projection, the patient lies on his back on the Bucky table. A 14 x 17 cassette is placed so that its middle is under or slightly above the iliac crests. The body should be well straightened and the feet brought together. The central ray is perpendicular. Respiration is stopped during exposure.

For the lateral view the patient lies on the side with the legs slightly bent. Care must be taken that the patient does not deviate either way from the true lateral and that he is not brought too far forward as the border of the lumbar vertebra is well anterior of the tips of the spinous processes. Centering is the same. A folded pad of cloth placed above the iliac crest will help keep the spine straight.

Additional views:

1. R. & L. obliques are frequently desired and are made with the patient rotated 45 degrees. Centering is as before.

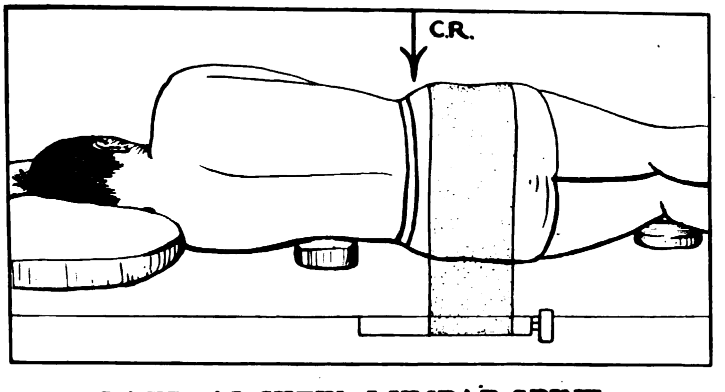
2. Lumbo-Sacral articulations.

A 10 x 12 cassette is placed under the sacrum and lower lumbar spine, in the Bucky tray. The X-ray beam is angled toward the head about 35 degrees from the vertical and passes through the articulation.

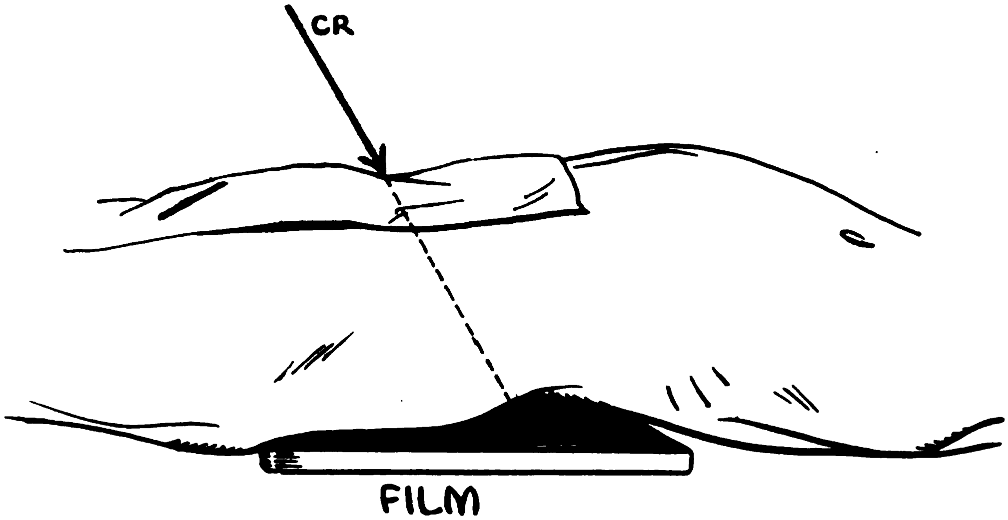
3. Lateral Sacrum and Coccyx.

The patient lies on the side with 10 x 12 cassette extending a few inches below the coccyx. The X-ray is perpendicular and its central ray should pass through the mid-sacral region.

4. Sacro iliac joints: For these angle the tube 10 x 25 degrees toward the head. The patient is supine. If oblique views are desired rotate the patient 25 - 30 degrees from the supine position and center the tube one inch medial to the anterior-superior spine of the raised side.



LATERAL VIEW, LUMBAR SPINE



LUMBO-SACRAL ARTICULATION

SKULL:

Conventional views:

These include P.A., A.P. and R. & L. laterals. The postero-anterior projection may be carried out with the head resting either on the nose and forehéad, or on the chin; or both views may be made. The antero-posterior view is made with the head resting on the occiput and the central ray either vertical or angled toward the feet 45 degrees; again both views may be desired.

The exact program of views will depend on the condition suspected and the preferences of the roentgenologist. For general purposes it is best to take four or five projections. Some or all of these may be stereoscopic in accordance with the condition under investigation and the desires of the medical officer in charge. A set that will answer most purposes is as follows:

(1) P.A. Projection, stereoscopic, with the head resting on the chin and the nose 1 to 2 cms. above the table. This set will visualize the facial bones and the maxillary sinuses along with the anterior portion of the cranial vault.

(2) P.A. Projection, single film, with the head resting on nose and forehead. This view shows more of the anterior portion of the cranium, and shows the frontal sinuses and ethmoidal cells to fair advantage.

(3) R. Lateral stereoscopic views.

(4) Left Lateral, single film. This should be centered one inch above and one

inch in front of the external auditory meatus so as to obtain a true lateral view of the Sella Turcica and sphenoidal sinuses. A sharply coned view of the Sella may be desired when a tumor is suspected in this region.

(5) A.P. Occipital View, single film, with 45 degree angulation of the tube toward the feet. This brings into view the occipital bone up to and including the foramen magnum and so is important in diagnosing fractures of the base in the posterior fossa. The petrous ridges and portions of the pituitary fossa (sella turcica) are also visualized.

Additional views:

1. Axial Verticosubmental:

The head rests on the chin and is tilted backward as much as possible. The central ray is angled so as to pass slightly in front of the ear and parallel to a line joining the forehead and chin. This view shows the sphenoidal sinuses and surrounding structures quite well. It can be made to advantage with a small cone or cylinder, without the Bucky.

2. Axial, submentovertical:

The patient rests on the back with a thick cushion under the shoulders so that the head can be tilted far back. Once more, the central ray is parallel to a line joining the forehead and chin. It should enter the floor of the mouth two inches posterior to the point of the chin. Either the Bucky or a small cone or cylinder may be used. The former will, of course, give good detail over a larger field. A number of structures in the base of the skull are shown.

Sinuses:

1. Caldwell, or nose-forehead projection:

The head rests on the nose and forehead and the central ray tilts toward the feet about 23 degrees. It should pass through the orbit. Special plate holders, adjustable to various angles may be used for this work. In such case the plate can be angled 23 degrees and the X-ray beam kept vertical. These plate holders call for use of small cones or cylinders.

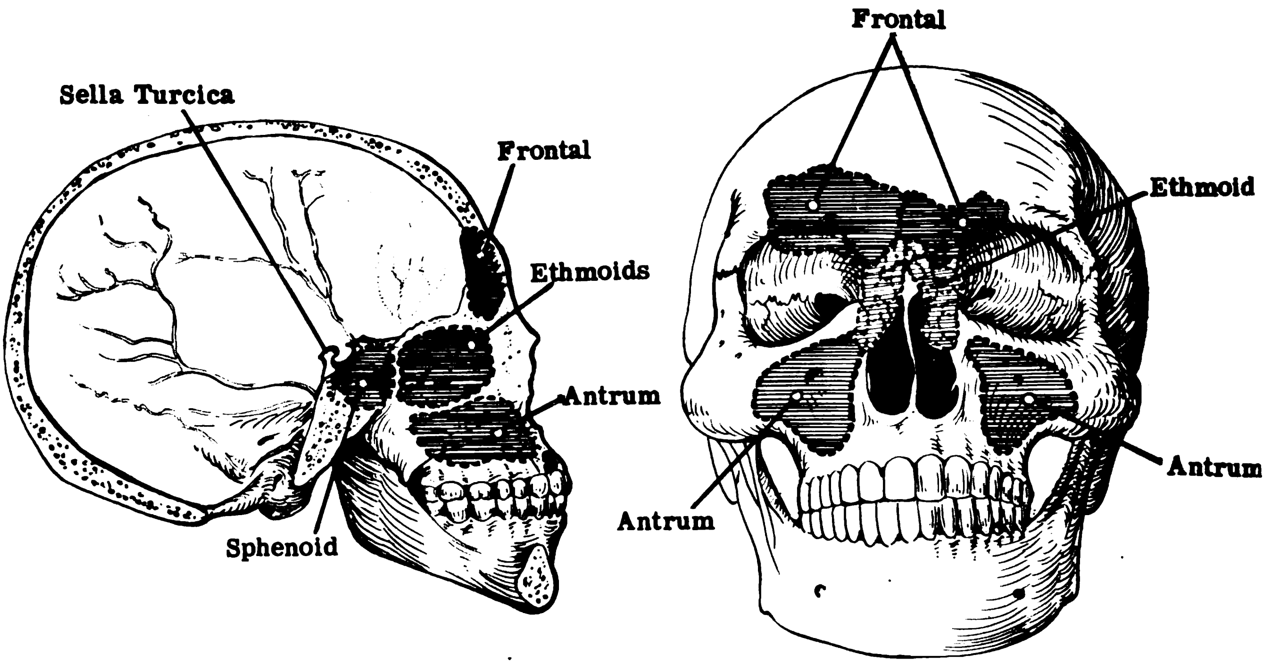
The frontals show particularly well in this projection. The ethmoidal cells also show though the sphenoidal sinuses are superimposed and may cause confusion. The turbinates and nasal septum are shown.

2. Waters, or nose-chin projection:

The head rests on the chin with the nose 1.5 cms. above the table or plate. This distance should not vary more than 0.5 cms. The central ray is perpendicular and passes through the tip of the nose. This view shows all the sinuses except the sphenoid. If the tilt of the head is correct, the antra will be almost entirely in the clear. Insufficient tilt of the head (the nose allowed to flatten out on the table) will

result in the petrous portions of the temporal bones throwing dense shadows over a large portion of the antra. Slight rotation of the head to one side or the other, will blot out most of the ethmoidal cells on one side. This view is preeminently to visualize the antra. It also shows most of the zygomatic bones and if the nose is lifted another cm. higher from the plate the zygomatic arch will be fairly well shown. The orbits also show to advantage. Thus this type of view is of great value in fractures of the facial bones.

If it is desired to visualize fluid levels in the antra, upright films in the Waters position should be made.



3. Granger, 107 degree position:

A 17 degree sinus board with an opening for the nose is used with the open end of the angle at the neck and the apex under the forehead. The head rests on the upper lip and forehead. The central ray is vertical and passes through the external auditory meatus.

In this view the petrous ridges are projected through the orbits. Part of the sphenoid sinuses show between the uppermost portions of the orbits and free pus may be demonstrated in some cases.

4. Granger, 23 degree position:

The sinus board is placed on a 23 degree angle block or other support, the apex of the angle being toward the neck. The X-ray beam is directed vertically through the external canthus of the eye. The sinuses show well except for the sphenoids but the lower halves of the antra are obscured by the petrous portions of the temporal bones.

5. Sinuses, lateral:

The head is turned to the true lateral position and the central ray passes vertically through a point midway between the ear and the external canthus of the eye.

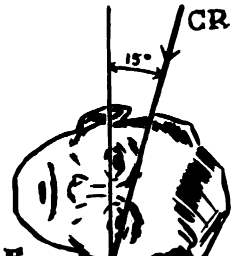
6. Sinuses, open mouth sphenoid position:

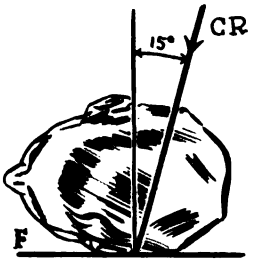
The head rests on the nose and chin with the mouth wide open. The tube is angled about 25 degrees toward the feet, the central ray passing through the open mouth. This makes a useful routine view of the sphenoids; they are, of course, projected through the open mouth.

The choice of which of these various views to make rests with the roentgenologist, and naturally depends also upon the sinuses under suspicion and other attendant circumstances. A good set of views which will answer most purposes is as follows:

1. Caldwell position (nose-forehead).
2. Waters position (nose-chin with nose 1.5 cms. above plate).
3. Lateral sinuses.
4. Open-mouth sphenoid.

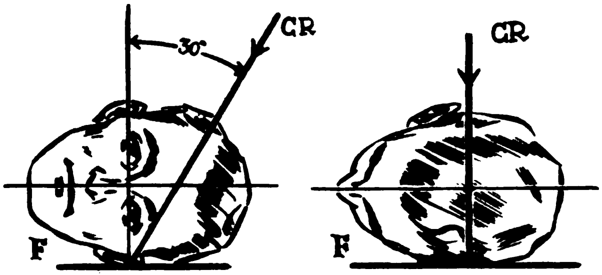
Note: These positions are all diagrammed in the following pages.





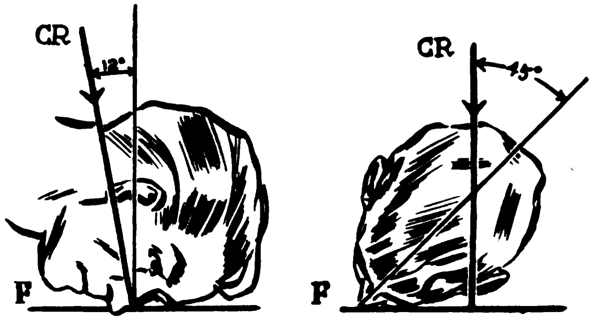
MASTOID, LAW

Meatus placed in center of cassette. Sagittal plane parallel to film. Central ray enters two inches above and behind the upper meatus at angle of 15 toward feet and face.



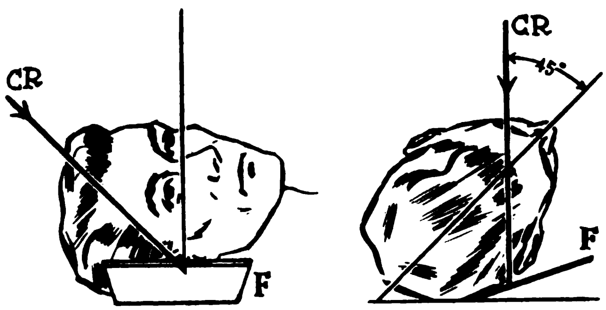
MASTOID, SCHULLER

Patient prone. Ear folded forward. Sagittal plane parallel to film and horizontal plane perpendicular to table. Tube tilted to feet at angle of 30° with horizontal plane of skull. CR enters above ear through and out opposite meatus.



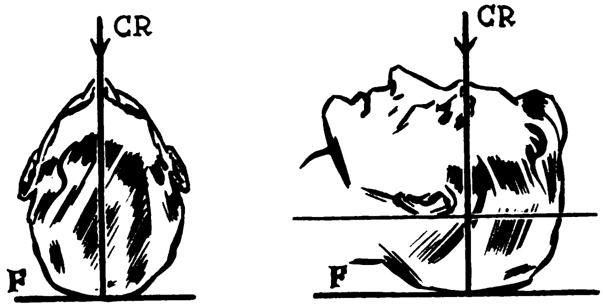
PETROUS BONE, STENVERS

Patient lies prone with forehead, nose, and malar bones on cassette. Sagittal plane at 45 angle to cassette. Horizontal plane perpendicular to film. Tube tilted to head with CR at 12° to horizontal plane passing through mastoid on film.



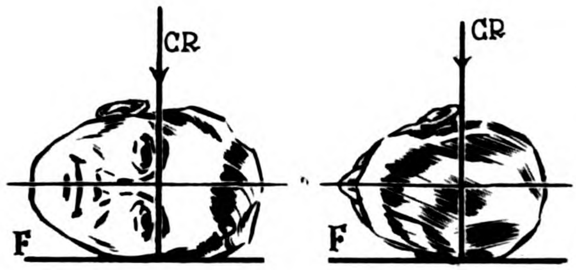
PETROUS BONE, MAYER

Patient on back. Head 45 degrees to side taken. Ear folded forward. Cassette held against ear by sandbags. The meatus of ear in center of cassette. Tube tilted toward feet at 45 degrees with horizontal plane, enters above the supra-orbital ridge of opposite side.



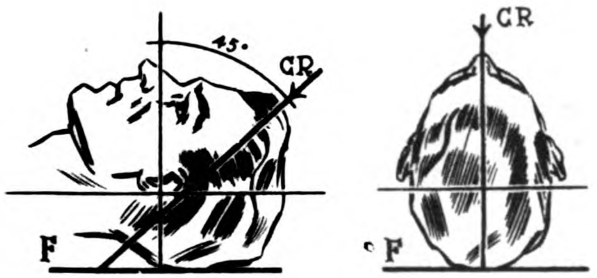
PETROUS BONE, A. P. VIEW

Central ray perpendicular to film. Patient on back with sagittal plane perpendicular to table. Central ray extends through midplane along Reid's Base Line.



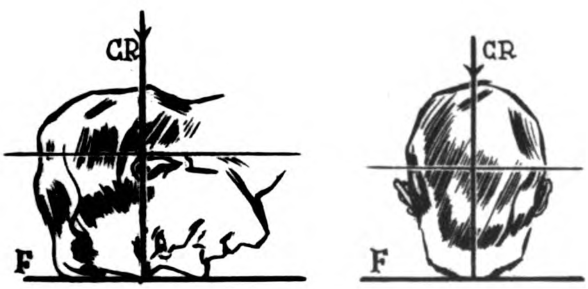
SKULL, LATERAL

Patient prone. Sagittal plane parallel to table. The central ray is perpendicular to film and enters the head one inch above and one-half inch anterior to external acoustic meatus.



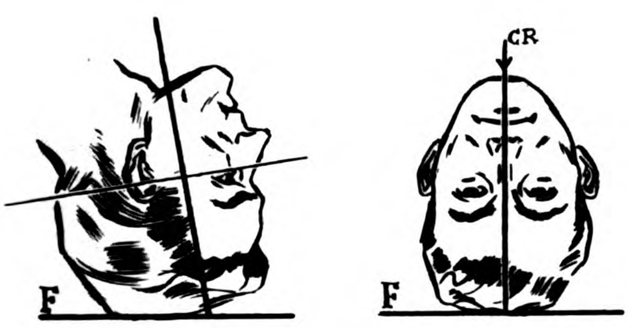
SKULL, A. P. OCCIPITAL

Patient on back with horizontal plane perpendicular to table. Tube tilted toward feet 45 degrees. CR. centered midway between external acoustic meatuses.



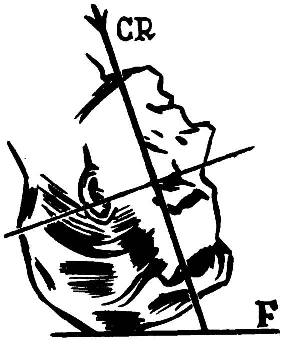
SKULL, P. A.

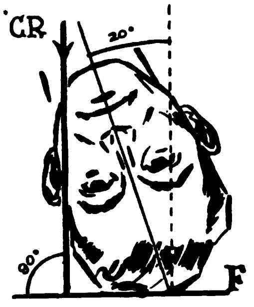
The patient lies face down with forehead and nose resting on Bucky table. The upper border of cassette two inches above the head. The central ray is perpendicular to table.



SKULL AXIAL SUBMENTOVERTICAL

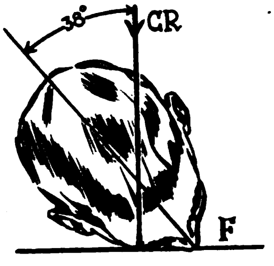
Patient lies on back with sandbags or other support under shoulders. The head is tilted backward until horizontal plane is about parallel to table. The central ray enters two inches below point of chin, parallel to vertical plane.





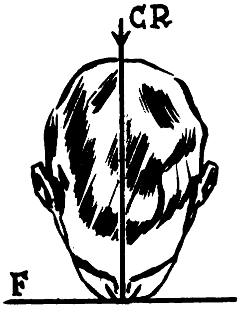
ZYGOMATIC ARCH

The patient lies with head thrown back as in basal skull, except that the head is angled 20 degrees toward the side taken. The central ray passes through the angle of the jaw and zygomatic arch. The ray is perpendicular to the cassette.



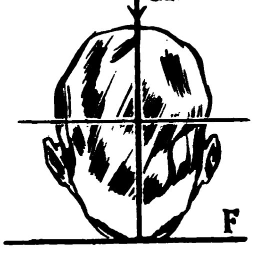
OPTIC CANAL

Nose, malar eminence and chin rest on cassette. The sagittal plane makes an angle of 38 degrees with the vertical plane. The beam is centered over the orbit nearest the film and is perpendicular to the cassette. (See text for use of Camp localizer).



SPHENOID, OPEN MOUTH

Patient lies in prone position with nose and chin touching cassette. The mouth is opened and the central ray is directed 25 degrees toward feet so that the ray emerges through the open mouth.

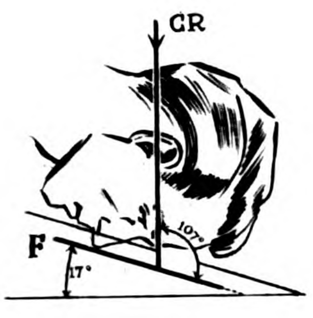


SINUSES, CALDWELL

Patient lies prone with forehead and nose touching cassette. CR. passes through horizontal and sagittal plane. Tilt tube in line with acoustic meatus and lower border of orbit. (23 degrees).

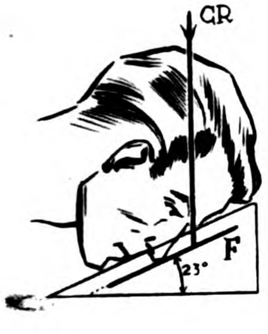
SINUSES, WATERS

Patient lies prone on table with chin on cassette. The nose 1.5 cm. from cassette. CR. is perpendicular to film and passes through the tip of nose.



SINUSES, GRANGER...107

A 17 degree sinus board is used. CR. is vertical passing through sagittal plane on line with acoustic meatus emerging about the glabella.



SINUSES, GRANGER....23

The patient lies prone on 23 degree sinus board. CR. is directed vertically through sagittal plane and at the level of the external canthus of the eye.

Mastoids:

1. Law or "double 15 degree" view:

The head rests in true lateral position and the X-ray tube is angled 15 degrees toward the feet and 15 degrees anteriorly (toward the face). The central ray enters the skull about two inches above and two inches behind the external auditory meatus so that it emerges from the opposite meatus next to the film. If the Bucky is used, it will be undesirable to angle across the grid. In that case the face may be tilted downward to produce the desired angle. It might be noted that when the patient lies prone with the head turned to the side and resting on the table it will naturally approximate the 15 degree angle. The auricle is usually folded forward.

The Law position has been used a long time and is generally satisfactory.

2. Schuller position:

For this, the head is placed in true lateral position. (The fist placed under the chin makes a good support to maintain this position). The X-ray tube is angled toward the feet 30 degrees and the central ray enters the skull above the upper external auditory meatus so as to emerge from the lower meatus.

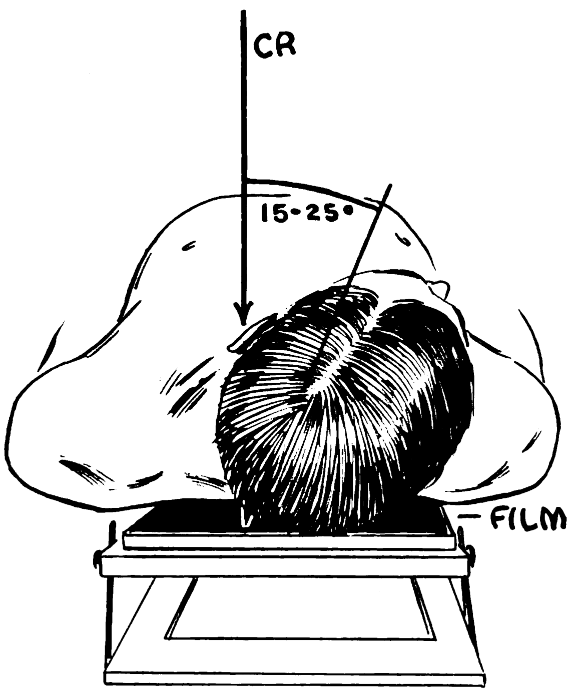
This projection is easy to make as it requires measurement of only one angle, and does not interfere with use of the Bucky. However, most workers prefer the use of small cones or cylinders to the Bucky. Use of the Bucky with a small cone or cylinder, of course makes particularly brilliant views.

The results of the Schuller position are not notably different from those of the Law.

2. Profile View:

The head rests with the occiput on an angle board tilted to a 15 - 25 degree angle, the apex of the angle toward the neck. The head is rotated away from the affected side about 35.degrees, the chin being kept well down. The side to be radiographed is thus the upper. The X-ray tube is vertical and the central ray passes through the upper mastoid process.

The resultant view shows the mastoid tip and antrum. Sandbags or a solid angle block may be used to replace the angle board. Cones or cylinders should be used.



PROFILE VIEW FOR MASTOID TIP.

Petrous Bone:

1. Stenvers position:

The patient lies face down with the head rotated 45 degrees toward the side to be radiographed and thus resting on forehead, nose and malar bone. The tube is angled upward 12 degrees and the central ray should pass through the mastoid nearest the film. This view is used to help determine the degree of spread of ~~any of~~ mastoid infection into the petrous pyramid and also for other purposes such as the diagnosis of tumors.

2. Mayer position:

For this the patient is supine and lies with the head rotated 45 degrees toward the side to be radiographed. The tube is angled 45 degrees toward the feet and the central ray enters the skull well above the orbit of the opposite side so that once more it will emerge through the mastoid next the film.

Small cones or cylinders are preferred for this work.

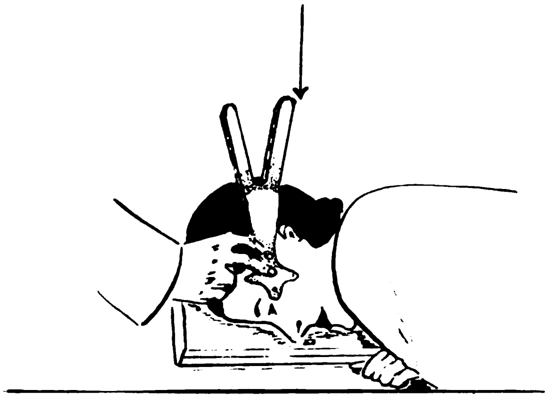
In general, both sides should be radiographed in all mastoid and petrous bone cases.

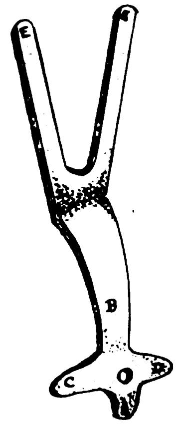
A number of other views are described for visualizing the petrous bone, some of which are illustrated in diagrams (see chart). The above, however, will answer most purposes, perhaps combined with an A.P. projection which will show the petrous ridges through the orbits.

Optic Canals:

To visualize these the patient lies face down with the head rotated 38 degrees toward the side to be radiographed, (angle measured from the vertical). The central ray is vertical and should emerge from the orbit next the plate. The head should rest on nose, chin and malar eminence. The diameter of the canal averages 4.3 mm.

A useful aid in obtaining this view is the Camp Localizer. This is a "V" shaped metal device, about 11 inches long, the vertex of which is slightly curved and provided with a short cross piece. When the patient's head is positioned on the table with the orbit in question immediately over the cassette (nose, chin and malar eminence in contact) the localizer is applied to the head and used as a guide in the following manner: The apex, point A, is placed at the outer canthus of the opposite orbit, with the limbs of the "V" extending vertically along the head and above the ear. The "V" is now arranged so that the edge nearest the ear comes in contact with the upper attachment of the ear to the head. The curve and cross piece of the "V" make possible snug and secure contact with the head. The final point is now to adjust the head so that this same limb which has just been placed in contact with the ear coincides with the central ray of the X-ray tube. This ray is vertical to the cassette. The target screen distance should be 30 inches.





USE OF CAMP LOCALIZER FOR OPTIC CANAL

The novice is apt to wonder here what the other limb of the "V" is for. The answer is simple; it is for use with the other orbit, as will become obvious when the instrument is put in operation. Error is scarcely possible if the concave aspect is applied to the head, as is of course the only natural method of procedure.

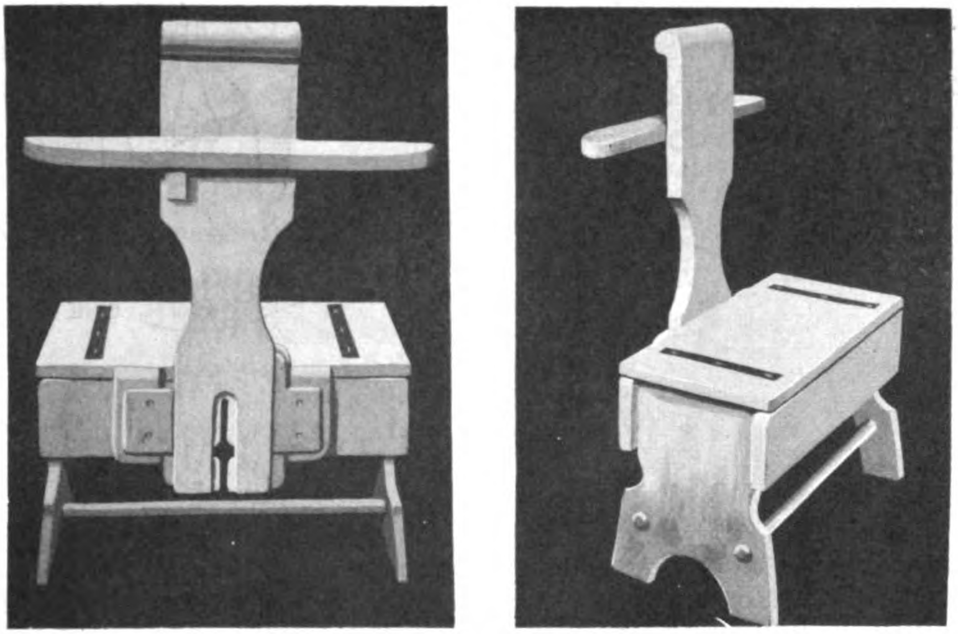
Encephalograms and Ventriculograms:

In these, visualization of the ventricles of the brain is obtained by a series of radiographs made after the cerebro-spinal fluid is replaced by air, oxygen or helium. In the former the fluid is removed and air injected by means of spinal taps. In the case of ventriculograms small openings are drilled in the cranial vault and the operation conducted by means of needles inserted directly into the ventricles. The patients are sometimes under the influence of an anesthetic and always require careful attention. Be sure to have sufficient help available to manage these cases. The views to be taken depend on the preferences of the roentgenologist and neurosurgeon, and the nature of the case. In general the views required are about as follows:

1. With the patient on the table views are taken in both lateral projections, A.P. with vertical ray and P.A. with the patient in nose-forehead position.

In the lateral views the tube is centered on the middle of the skull. In the A.P. view the ray in centered on the middle of the forehead; likewise in the P.A. view. No angulation of the X-ray tube is used.

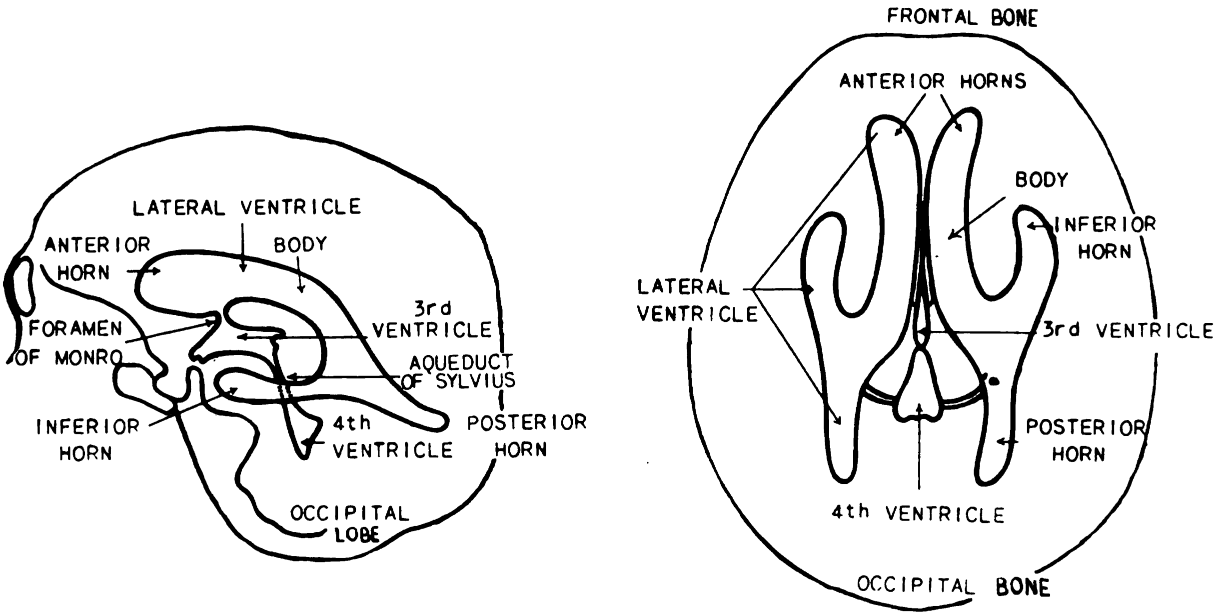
2. The same views are repeated with the patient upright, and the X-ray tube directed horizontally, and perpendicular to the film. Sturdy head clamps, a vertical Bucky, and a chair that will afford good support to the body should be available for this work, especially if the patient is unconscious or stuporous.



CHAIR FOR ENCEPHALOGRAPHY

3. If for any reason views with the patient upright are impracticable, then it is well to take a set of views in the four projections outlined, with the patient on the table as in the first set but with X-ray tube horizontal. It may be necessary to make use of a mobile X-ray unit to accomplish this.

The reason for the numerous positions is to ensure that the air has opportunity to reach all parts of the ventricular system and be recorded on the radioraphic plate. Otherwise failure of some part of the system to visualize in the radiographs might occur due purely to technical factors and not to pathological abnormalities; confusion in interpretation might thus easily arise.



VENTRICULOGRAPHY -

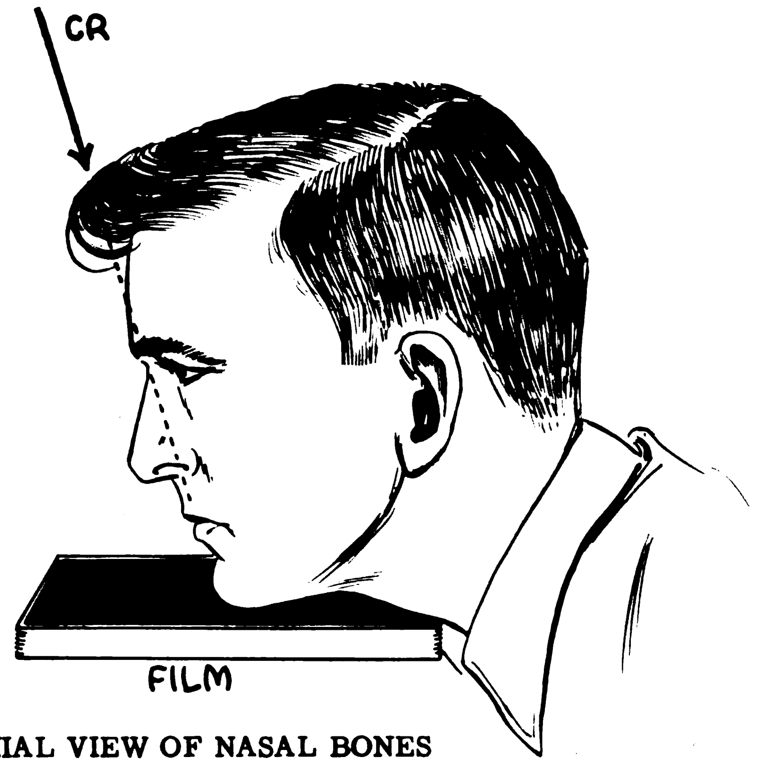
Pineal Body:

Views for measuring any possible displacement of the Pineal include the routine true lateral centered over the mid-portion of the skull and P.A. view in the nose-forehead position. Its shadow normally lies 4.0 to 5.0 cms. above the horizontal plane of the skull and about 0.5 to 1.5 cms. posterior to the vertical plane. The line of the horizontal plane is drawn from the lower border of the orbit through the upper margin of the external auditory meatus. A line drawn perpendicular to this horizontal line, and passing through the center of the external auditory meatus, constitutes the line of the vertical plane.

Facial Bones:

The malar or zygomatic bones as already noted show well in the exaggerated Waters position, i.e., P.A. View with the nose well up from the plate and the head resting on the chin. The central ray passes through the tip of the nose. Stereos are often helpful, and occasionally oblique views. The regular lat. sinus view may be needed.

To visualize the zygomatic arch,without foreshortening,the patient is placed in the supine position with the shoulders elevated on a thick pad or cushion and the head tilted back as far as possible. The head is then rotated about 20 degrees toward the affected side. The central ray is directed tangentially through the zygomatic arch and with sufficient tilt to parallel the line joining the forehead and chin.



AXIAL VIEW OF NASAL BONES

Nasal Bones:

The lateral view is made with the head in true lateral position. The central ray passes through the middle of the nose. A small cone or cylinder should be used. A common error is to use an exposure suitable for the lateral skull. This is entirely too much. The exposure required is about that used for the hand.

The axial view of the nasal bones is best made with the patient sitting on a stool with the chin resting on the end of cassette or plain film holder. The central ray passes through the nose along the line joining the forehead and chin.

Maxillary Bones:

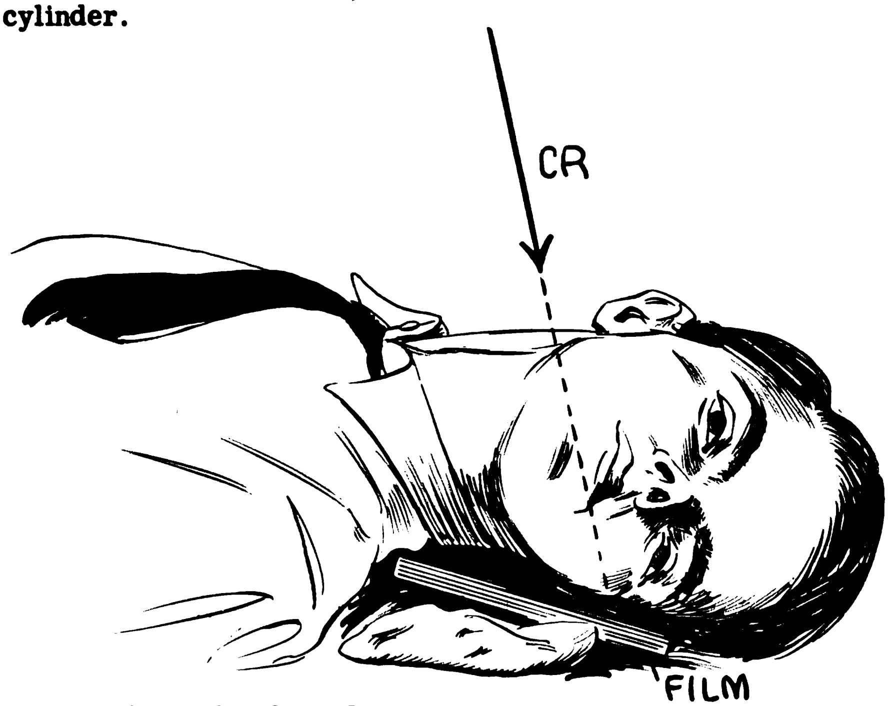
The view in the nose-chin position shows the maxillae. This may be supplemented by a P.A. projection with the head resting on nose and chin and the central ray angled 20 degrees toward the top of the head. It should enter the skull about 1-1/2 inches below the occiput so as to emerge in the region of the mouth. A small cone or cylinder should be used.

An intra-oral view is often desired in case of injury to maxilla. This is readily accomplished by placing an occlusal type of dental film horizontally in the mouth. The central ray is directed perpendicularly to the film. Additional intra-oral views may be made by angling the tube toward the back of the head so that the central ray is directed through the tip of the nose to the center of an occlusal film or again by angling the tube across from one side of the nose just beneath the orbit. Dental tubes are naturally very convenient for this type of work and as a matter of fact dental personnel frequently take care of this type of work as injury here often involves the teeth.

In the absence of a dental unit, good views can of course be obtained by resorting to small cones and cylinders.

Mandible:

P. A. and Lateral oblique views are called for. For the first the head rests in the nose-forehead position. The central ray is directed so as to pass through the mid-point between the mandibular angles and is tilted 20 degrees toward the top of the head. The lateral oblique view may be made either with the patient prone or supine. When the patient is supine, the head is turned to the affected side with the jaw resting on the cassette (5 x 7) and the cassette supported by a sandbag so that its lower end is higher than the upper thus making an angle of about 15 degrees. The tube is tilted toward the top of the head 15 to 20 degrees and the central ray enters the neck just below the angle of the upper jaw to pass through the affected side. Use cone or cylinder.



LATERAL OBLIQUE MANDIBLE

For the view with the patient prone, the head once more rests on the affected side about 10 degrees beyond true lateral. The central ray is angled about 30 degrees toward the top of the head and passes through the middle of the affected side of the mandible. Use small cone or cylinder. The Bucky may also be used for this view.

Various intra-oral films are often needed by reason of injury to the teeth. An occlusal film made with the X-ray directed up through the floor of the mouth is useful when the anterior portion of the mandible is to be examined.

Temporomandibular Joints:

The patient lies prone with the head in true lateral position and the central ray is angled toward the feet 20 to 25 degrees, entering the skull above the upper

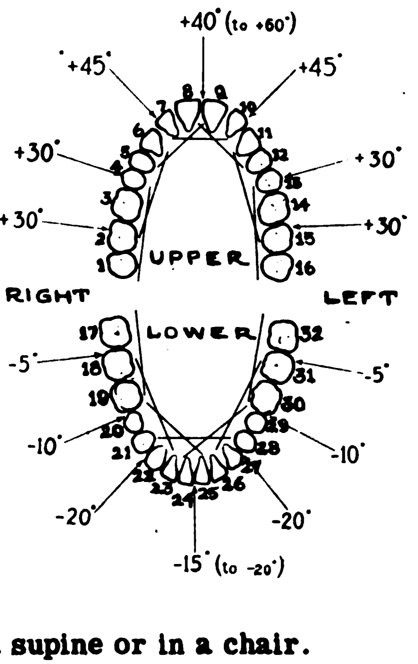
ear and emerging through the temporomandibular joint nearest the film. Two views are usually taken of each joint, one with the mouth open and the other with the mouth closed. In making the latter view it is important that the mouth be closed in the patients regular bite as it is often desired to find out whether or not the bone relationships are normal, in that position. The 23 degree angle board designed for sinus work may also be used for these views. In this case the head is placed over the board in lateral position, the apex of the angle being, of course, toward the top of the head, and the base under the neck. The X-ray tube is vertical.

Teeth:

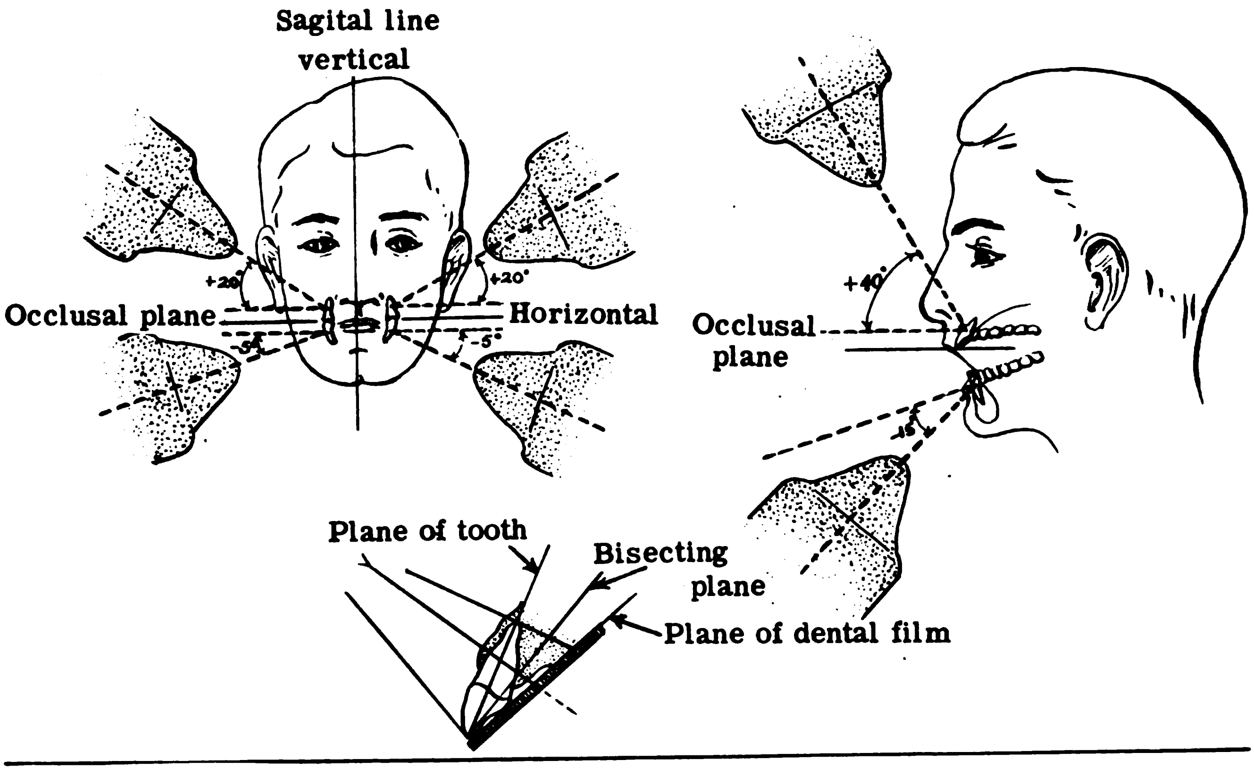
Dental radiographs are practically always taken by dental technicians in the dental laboratories. Nevertheless, these views can be made in the X-ray department in case of necessity, employing the regular apparatus. However, the mobile unit may be easier to manage.

Some ingenuity and an ability to visualize angles are necessary for the best work although a system of fixed angles will answer fairly well. The films are, of course, placed intra-orally against the crowns of the teeth and the gums and the X-ray beam directed so as to obtain a clear view of the teeth with a minimum of distortion. It is impossible to fix the film in a position perfectly parallel to the teeth and to obtain minimum distortion, the central ray is directed neither perpendicular to the teeth nor the film but to a plane bisecting the angle between them. Fourteen or sixteen films are usually required for a complete set. The following diagram will indicate the usual angles the central ray makes with the occlusal plane of the teeth. The upper teeth require a downward tilt of the tube and angles are marked with plus signs. The lower teeth require an upward tilt and the angles are marked with minus signs.

	Upper	Lower
MOLARS	1-2-3 14-15-16	17-18-19 30-31-32
BICUSPIDS OR PREMOLARS	4-5 12-13	20-21 28-29
CANINE OR CUSPID	6-11	22-27
LATERAL INCISORS	7-10	23-26
CENTRAL INCISORS	8-9	24-25



Films can be made either with the patient supine or in a chair.



The patient should invariably hold the films in place himself. The technician places whichever of the patient's index fingers is required, firmly in place against the back of the film. For the technician to hold the film in place himself is to court certain disaster unless the volume of work is most extraordinarily small.

Occlusal dental films are larger than the regular dental films and are placed between the teeth, extending to the last molars. For the upper teeth the central ray passes through the bridge of the nose at right angles to the film. For the lower teeth the head is tilted back and the central ray directed through the floor of the mouth about 1-1/2 inches posterior to the point of the chin, perpendicular to the film. This view is also useful for diagnosing the presence of calculi in the salivary duct (Wharton's) in the floor of the mouth.

<u>Chest:</u>

Sternum:

P.A. and lateral views are called for. For the former, the usual technique calls for the patient to lie face down with the sternum over the Bucky and his <u>right</u> side lifted about three inches from the table, so that the spine will be projected to the left. The central ray is directed through the sternum and will usually enter the body about two inches to the right of the mid-line. The patient must hold his breath

during the exposure. A 10 x 12 or 11 x 14 cassette should be used. If the prone position is too painful, the examination can be carried out with the patient upright, merely employing the upright cassette changer.

Another method for the P.A. projection and one which will yield superior results, is based on the use of a short anode film distance, plain film and angulation of the tube. This must be shockproof.

A 10 x 12 film in a plain holder is placed about 5 inches above the table top by employing either a special box or any convenient support such as sandbags. The patient bends over from the standing position and rests the chest on the film so that the sternum is in the middle and the edge of the film reaches the lower portion of the neck.

The tube carriage angled toward the patient's right side (15° for thick chests to 20° for thin) is brought down to actual contact with the patient's back in such position as to project the C.R. to the middle of the film.

A long exposure is preferable and the patient is instructed to breathe normally. 50 M.A.S. at about 55 Kv.P. are average factors. Low M.A. should be employed if possible--preferably 5 or 10. Small mobile units are excellent for the purpose.

For the lateral view, the patient lies on the side with arms extended over the head, and the sternum centered over the Bucky. The central ray passes vertically through the sternum, and at right angles to the film.

Ribs:

In order to properly visualize all the ribs, exposures will have to be made both for the ribs above and the ribs below the diaphragm. This is because the density of the lungs is much less than that of the abdomen.

For the ribs above the diaphragm the conventional six foot view for lungs and heart will yield good results, preferably with a slight increase in the K.V.P. used. This is not always practicable to carry out and it is more customary to radiograph the ribs with the patient supine with the rib cage over the Bucky, employing a 14 x 17 cassette. The upper border of the cassette should extend into the lower cervical region. The X-ray tube is centered over the mid-dorsal region (6th or 7th dorsal vertebra). The breath must be held during exposure. No tilt of the tube is employed for this view. Stereoscopic views are often helpful.

For the ribs below the diaphragm, the lower border of a 14 x 17 cassette should extend slightly below the level of the iliac crests. The X-ray is centered on the xiphoid process. Exposure factors should be about the same as for the lumbar spine.

To visualize portions of the ribs in the axillary line oblique views with the patient rotated about 45 degrees from the supine may occasionally be needed. Again the upper ribs may be well shown by tilting the X-ray tube downward toward the feet 15 to 20 degrees. The exposure required is about the same as for the shoulder. The patient should be shifted so that the injured side is over the middle of the Bucky and the central ray passes through the infraclavicular region.

Lungs:

The conventional view of the lungs is a P.A. Projection made with the patient upright, and at a distance of 72 inches or 6 ft. The patient stands facing a vertical cassette holder or plate changer and leaning lightly against it with the chin resting on its top, the head tilted backward. The shoulders are rolled forward against the cassette holder to rotate the scapulae outward as much as possible. The hands are placed on the hips. Exposures are usually made at the end of normal or fairly deep inspiration. Occasionally an exposure may be desired after forced inspiration, forced expiration or both. For proper stereoscopy, both films should be made on one breath. Exposure time should be kept below 1/10th second if at all possible. The breath is, of course, held during exposure.

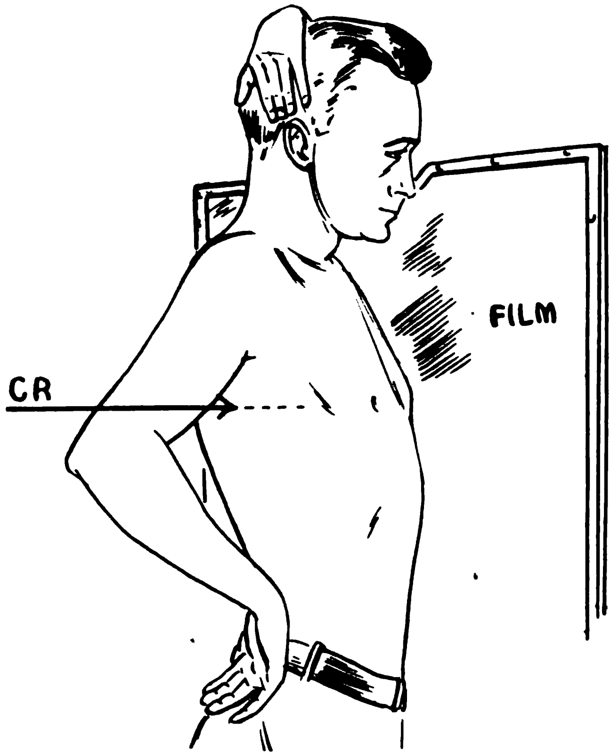
Additional views include lateral and oblique views and certain others.

(1) For the lateral view the patient stands with the side against the vertical plate changer with arms extended upward and the forearms resting on the head. If each hand grasps the opposite elbow steadiness will be improved. Exposure is made at the end of inspiration and the breath is held.

(2) Obliques: For the left anterior oblique view the patient places the anterior aspect of his left shoulder against the plate changer with the left forearm resting on his head. The right shoulder is brought out from the plate holder until the patient is rotated about 45 degrees. The right hand may be placed on the hip or rested on the top of the plate changer. This view shows the aorta very well. The right anterior oblique is made in the same manner as the left except that sides are naturally reversed. Rotation may be slightly increased to advantage for determination of the size of left auricle (55 degrees). Slightly less rotation answers best for the aorta (35 degrees). The oesophagus is well shown in the R. anterior oblique view. Fluoroscopy may be advisable in some cases to determine precisely the best angles to use for the oblique views.

(3) Semi-axial View: (Fleischner Position). For this, the patient faces the plate changer, grasps its sides and leans backward until his chest makes an angle of 45 degrees with the film. The X-ray tube is centered on the mid-dorsal region. This position renders the interlobar spaces more parallel to the X-rays and aids in the interpretation of certain puzzling shadows.

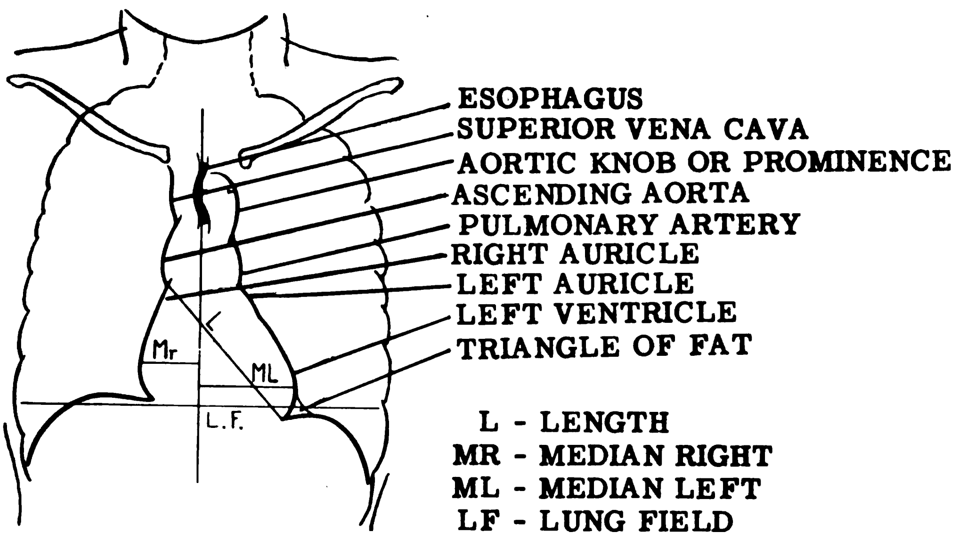
(4) Apical views: A semi-axial view made with the shoulders resting against the plate changer and the lower part of the body brought out from it for a considerable distance will aid in visualizing the apices. Again with the patient supine on the X-ray table a view can be made with the central ray angled 20 degrees toward the head. The patient's arms are crossed above the head to aid in removing the clavicles from the lung fields.



Heart: LEFT ANTERIOR OBLIQUE OF CHEST.

The same projections just discussed are used for the heart, with the exception of the apical and semi-axial views.

When cardiac measurements are desired, as is usually the case, it is important to use the 72 inch distance. Smaller distances cause more or less distortion that will prevent precision.



Abdomen:

Stomach:

For the conventional P.A. view, the patient is prone on the cassette or Bucky with the upper edge of the film almost reaching the nipple line. If but a single film is to be made, use a 14 x 17 cassette and center on its middle. When more films are to be made, use the 10 x 12 size. The location to be centered upon is often marked on the skin during the fluoroscopic examination; also any rotation to the right or left that may be desired, should be indicated on fluoroscopic notes. Exposures should be brief - not over 1/4 to 1/2 seconds.

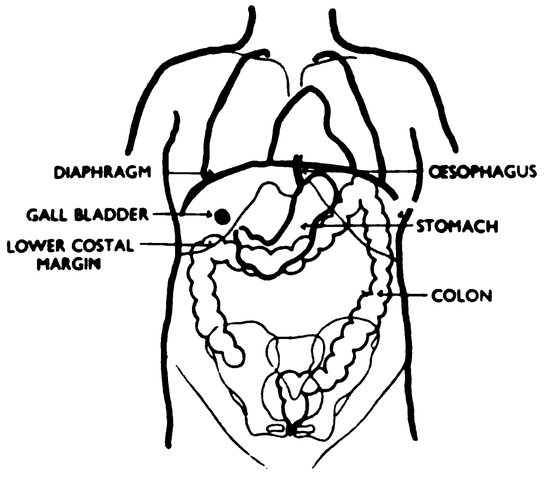
Additional views include oblique and supine studies as well as "spot" films.

(1) For the right oblique views the patient is prone and his left hip elevated from the table so that the body is about at a 45 degree angle. The left leg may be drawn up to steady the patient. A 10 x 12 cassette with the upper edge reaching the nipple line is used. The central ray is perpendicular to the middle of the cassette. Naturally positioning will be improved if the exact spot to be centered on is marked during the fluoroscopic examination which is normally part of any roentgenological examination of the stomach and duodenum. Exposures should again be brief. This right anterior oblique position (left hip elevated) usually produces good views of the duodenal loop and pyloric end of the stomach. The left anterior oblique (right hip elevated) is seldom used. Occasionally slight elevation of the right hip may be desired but not the full oblique.

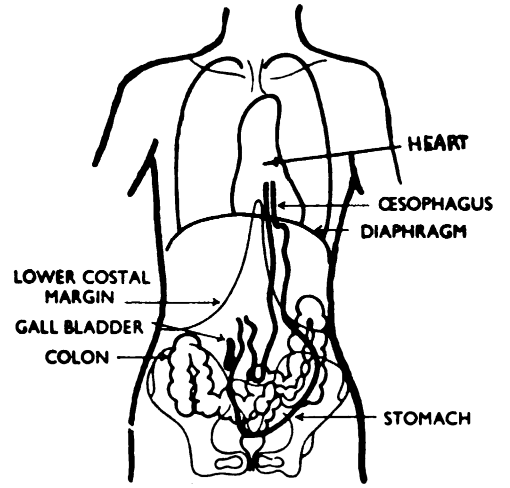
(2) Supine view: This is made in the same manner as the P.A. view, as regards centering. Its purpose is usually to visualize the cardia or fundus. The A.P. view can also accomplish this if the table is tilted to lower the head.

(3) Special serial views: These are made by means of a special plate tunnel which is covered with lead except for a rectangle 1/4th the size of the plate. The cassette tray is movable so that each of the four corners of the film can be brought under the open rectangle. Exact positioning of the patient is essential and should be done under fluoroscopic control, so that the particular part to be radiographed will not fail of inclusion. Sharp coning will improve results.

(4) Spot films: For these the fluoroscope is provided with a "switch-over" mechanism which will permit the operator to increase the current of the fluoroscopic tube to an amount suitable for rapid radiography. A special plate tunnel is also provided adjacent to the fluoroscope screen which keeps a small cassette (5 x 7 or 8 x 10) shielded behind lead, ready for immediate use. Electrical relays are usually provided so that when the cassette is slipped into place the current increase will automatically be arranged and the timer thrown into the circuit. Thus it is a very simple matter to obtain a view without any appreciable delay. The current increase is usually to 100 or more M.A. The time is usually between 1/4th and 1/2 seconds. A small Lysholm grid may be employed although if diaphragming is carried out to the greatest possible extent, sharp detail will be obtained without such. Means are also provided to apply compression, so that studies of mucosal relief will be facilitated. Some of these spot film devices provide for the taking of from two to four views on each film if desired.



HYPERSTHENIC TYPE



ASTHENIC

TYPES OF HABITUS

Colon:

The conventional view is the P.A. Projection. The patient lies face down with the abdomen over the 14 x 17 cassette, the lower edge of which should extend down to the tip of the coccyx. The central ray is centered on the middle of the cassette. The Bucky may be used. Positioning of the patient with the iliac crests or the navel in the middle of the plate will also be satisfactory in many instances. Exposure time should again not exceed 1/2 second if possible.

Additional views: Oblique or lateral views may be necessary to properly visualize portions of the sigmoid flexure, splenic flexure or other portions. The need for these must, of course, be determined by the fluoroscopic examination. Upright films may be desired to determine ptosis or for other purposes. They can be readily accomplished by use of the vertical plate changer or other device to hold the cassette in vertical position. Supine views may be used when the prone are difficult for any reason.

Small Intestine: Serial studies of the small intestine are not infrequently called for. Positioning as for the colon will answer most routine purposes. If the duodenum and upper jejunum are being studied, centering should be higher.

Extralumenal Gas: Views for the detection of such are called for when perforation of some hollow viscus is suspected (perforated peptic ulcer). A.P. views are usually advisable in both supine and lateral positions. The supine view should be made with the patient propped up to a 45 degree angle or if possible upright. The cassette is so placed that the diaphragmatic domes are clearly shown as the gas will naturally tend to collect at the highest point of the abdominal cavity. Thus the upper edge of the cassette should extend slightly above the nipple line. Use 14 x 17

size. The central ray is centered on the middle of the cassette. Bedside units must often be used for this work. In such case employ the wafer grid if possible. If not it may be well to supplement the large film by a sharply coned view centered over the dome of the diaphragm. For the A.P. horizontal ray view the patient is turned on the side, usually the left, and a 14 x 17 cassette placed lengthwise against his back. The mid-line of the cassette is in line with the iliac crests. The central ray is centered on the plate. The most important feature is to include the uppermost portion of the abdomen.

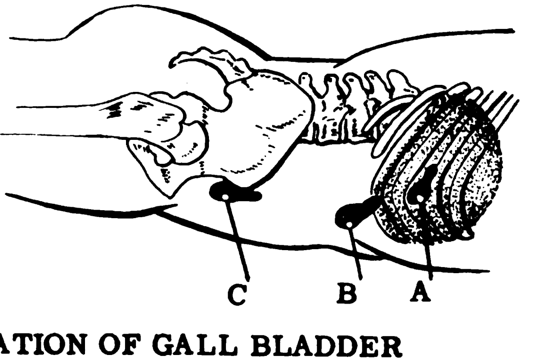
Note: Studies for intestinal obstruction in either large or small bowel should include an upright or 45 degree view so that fluid levels can be distinguished.

Gall Bladder:

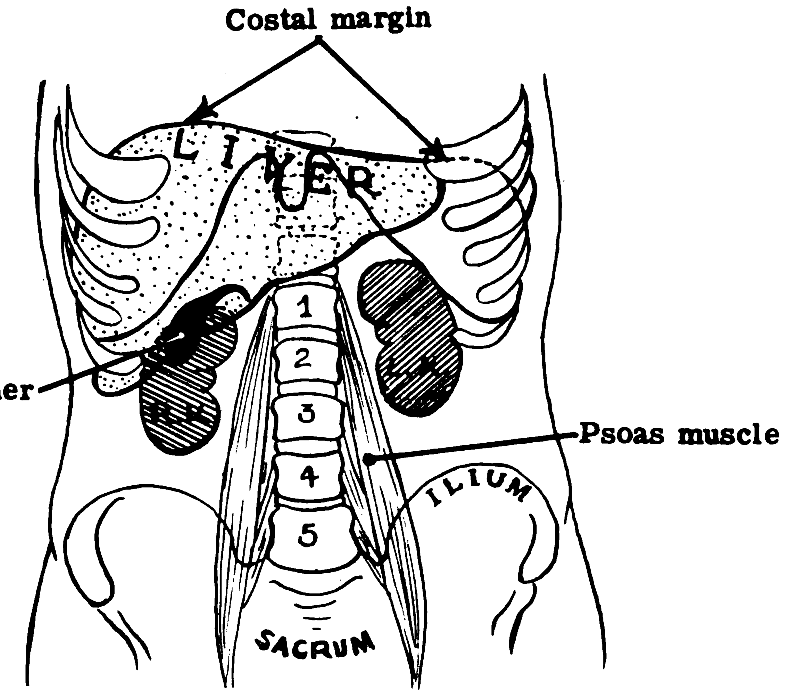
The conventional view is the P.A. Projection. The patient lies face down with the upper abdomen over the Bucky table and the body shifted to the left so as to place the right upper abdomen near the center. An 8 x 10 or 10 x 12 cassette is used in most cases and should extend from the right side of the patient to a point slightly beyond the spine. Since the gall bladder, in most instances, is near the costal margin, the center of film should be under that location. Its lower border should extend to the iliac crest. Since there is often considerable variation, it is a frequent practice to take two initial views of the gall bladder region at different levels. By inspection of these accurate localization can be accomplished and subsequent views sharply coned on small films. Needless to say the center of each initial view should be marked on the patient's back with a grease pencil or indelible pencil. In stout persons the gall bladder is higher and further to the right. In thin patients the gall bladder is much lower and nearer the mid-line. Short exposures of 1/2 second are desirable.

When the gall bladder is obscured by matter in the hepatic flexure as frequently happens, an enema may help considerably. Sometimes the medical officer may prescribe use of pitressin. Preliminary clearing out of the gastro-intestinal tract by use of castor oil or compound licorice powder may be indicated. A film made with the right hip elevated(left anterior oblique position) may be of use when questionable shadows are noted over the gall bladder shadow. Some elevation of the right hip is frequently of benefit to project the gall bladder away from the spine in thin persons. In all cases the X-ray is centered on the middle of the cassette. Upright views are rarely called for.

A Hypersthenic-Overstout
B Sthenic-Robust
C Asthenic-Thin



VARIATIONS IN LOCATION OF GALL BLADDER



Kidneys, Ureters and Bladder:

The conventional view is the A.P. projection. The patient lies on his back with the iliac crests over the middle of the Bucky. The film should extend from the lower margin of the pubic arch nearly to the nipple line. Thus in large individuals a single 14 x 17 film will not prove entirely adequate. In such case use a 14 x 17 film centered a few inches above the iliac crest or the umbilicus and cover the bladder region by an additional view on a 10 x 12 or 11 x 14 film,the lower end of which extends below the pubis. The central ray is perpendicular to the middle of the cassette. Rather brief exposures are desirable. The breath is, of course, held as should be the case in all work pertaining to the thoracic or abdominal viscera.

Films in the upright position are often desired in urological work, and a tilting table is desirable. The regular cystoscopic tables, fitted with X-ray installations, of course, permit of this.

When urograms are made either of retrograde or intravenous (excretion) type, the exposure technique and positioning remain unchanged from those mentioned above. At times an inflated rubber compression bag is held firmly over the bladder region by means of a compression band, in the case of an intravenous pyelogram to produce better filling of the pelves and calices of the kidneys. If water is withheld for 10 to 12 hours before carrying out an intravenous urogram, better density may be obtained. Enemas or other cleansing measures may be necessary in order to obtain satisfactory films. Castor oil and compound licorice powder are among the best laxative agents to use. The use of salines is frequently disappointing due to frequent development of gas shadows to a notable degree.

Additional views:

(1) Lateral views are often advisable to detect any anterior displacement of the kidney and also to better locate calcifications. The technique for the lateral lumbar spine will answer. Centering is the same as for the A.P. views. Naturally, however, if a lateral view of the bladder is desired, the centering will be over the suprapubic region.

(2) Oblique views of the bladder are sometimes called for. The patient is rotated 45 degrees from the supine position and centering is over the bladder region.

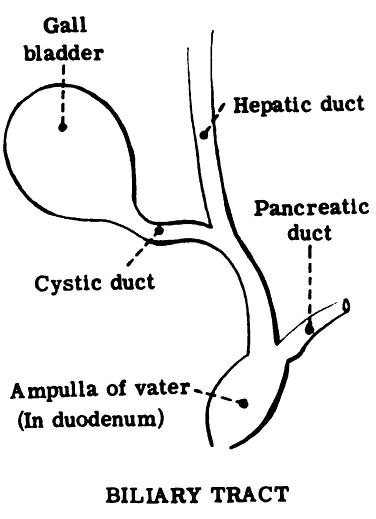
(3) Tilt view of Prostate: As already described under the "Pelvis" the central ray is angled 20 degrees toward the feet and passes through the level of the anterior superior spine of the ilium.

(4) Tilt view of the Bladder: The tilt is about 15 degrees toward the feet and the central ray passes through a point midway between the umbilicus and symphysis pubis. This is a good routine view for the bladder.

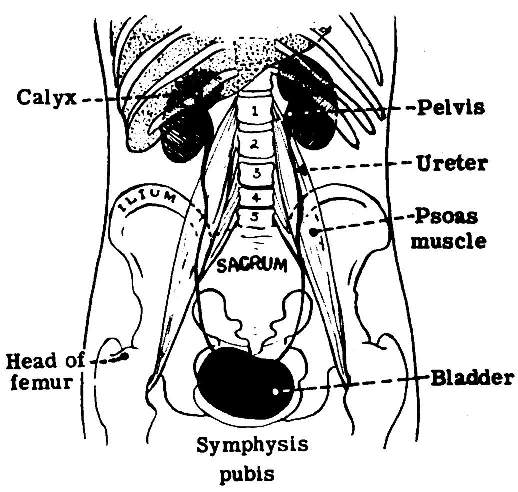
(5) Double shift view. For this two views are made on a single film, the tube being shifted laterally 3 inches between each view. The first is made with the tube shifted 1-1/2 inches to the right of the midline and the second with the tube 1-1/2 inches to the left. The object is to determine if a given opacity shifts with the ureter or not. Naturally a catheter must be in the ureter. If the opacity is in the ureter it will shift with the catheter. If it is at a different level than the ureter and accordingly not in it, the opacity will be in a different position relative to the catheter in the two views.

(6) Upright views, as already indicated are necessary to demonstrate ptosis.

(7) Views in the Trendelenburg position will often improve visualization of pelves and calices.



BILIARY TRACT



URINARY TRACT

Pelvis, Obstetrical:

The conventional views are A.P. and lateral. For the first, the patient lies on her back with the pelvis over the Bucky. A 14 x 17 cassette is placed with its lower border extending below the pubic arch. The X-ray beam is vertical and centered at the level of the iliac crests. Relatively short exposures of from 1/2 to 1 second are best. Otherwise, motion of foetus may produce blurring. In fact, occasionally in long exposures, the foetal outlines may entirely disappear due to motion. Stereoscopic films are often helpful.

For the lateral view the patient lies on her side on a Bucky Table or stands beside a Vertical Bucky with the pelvis precisely lateral. The lower edge of the cassette should extend several inches below the symphsis pubis. Centering is perpendicular to film at the level of the anterior superior spine of the ilium. A common mistake is to place the cassette too high and likewise center the X-ray too high.

Additional views:

(1) Pelvis, Obstetrical, Axial:

For this the patient sits over the Bucky table, leaning backward at an angle of about 45 degrees so that the pelvic inlet is approximately parallel to the film. Landmarks to use are the upper border of the symphysis pubis and the spinous process of the 4th lumbar: These should be the same height from the table.

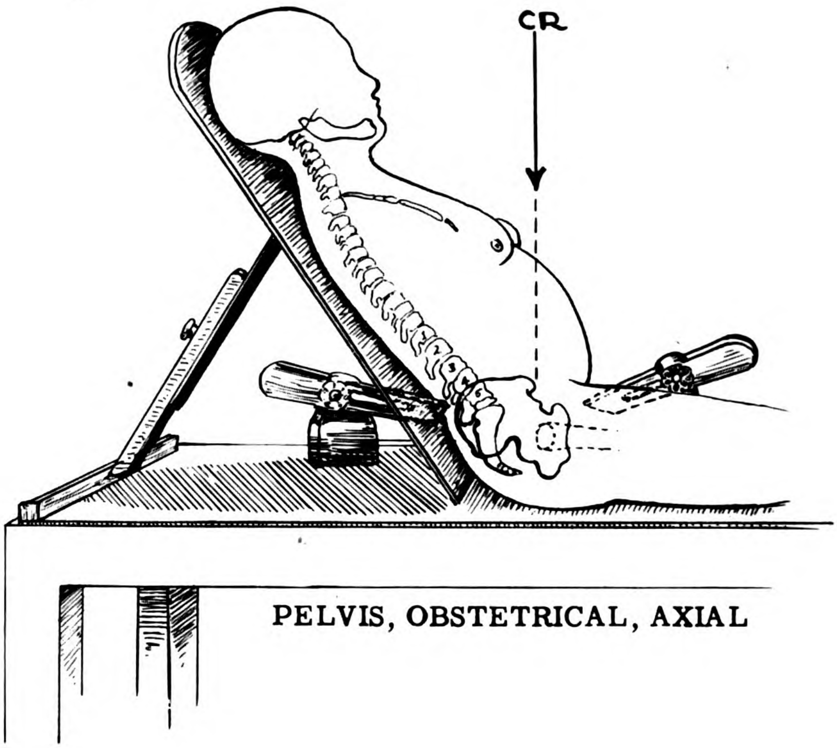
Pillows can be arranged to support the patient but if much of this type work is done it will be worth while to build an adjustable back rest.

(2) Pelvis, Obstetrical for Thom's Measurements:

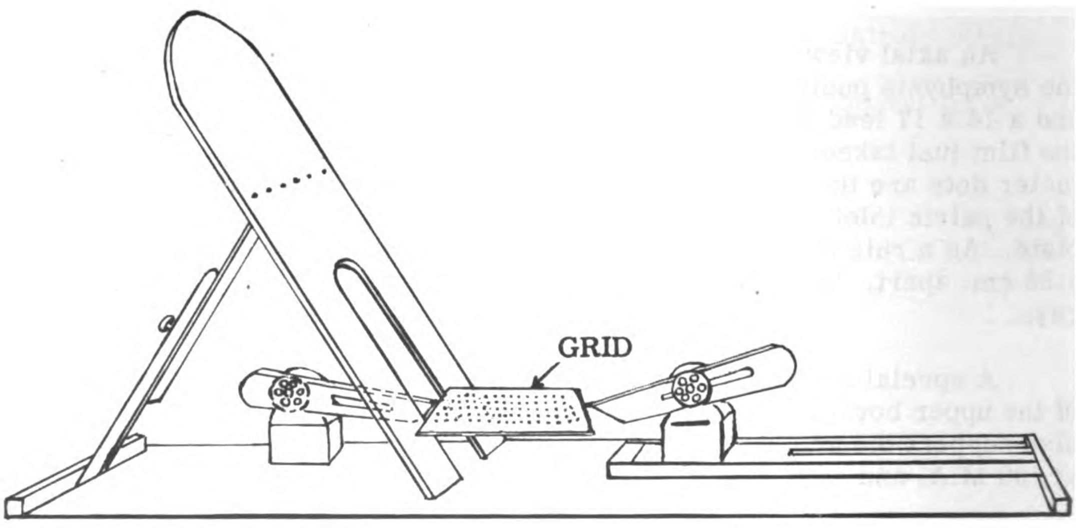
An axial view is made as just described and the height of the upper border of the symphysis pubis from the table measured. The patient then gets off the table and a 14 x 17 lead plate with small perforations a centimeter apart is placed over the film just taken at same level as the symphysis and given a brief exposure. Centimeter dots are thus superimposed on the film image and will indicate the true size of the pelvic inlet since both inlet and grid were at the same distance from the plate. As a rule the centimeter holes of the grid will produce dots on the film about 1.33 cm. apart. The magnification is, of course, the result of divergence of the X-rays.

A special support is easy to build incorporating devices to register the height of the upper border of the symphysis and the spinous process of the 4th lumbar and also support the grid for its exposure. Exposure of the grid is usually 1/5 second at 100 M.A. and 40 K.V.P.; 1/10 second at 55 K.V.P. will also do.

A plumb-bob suspended from the X-ray tube can also be used to register the height.

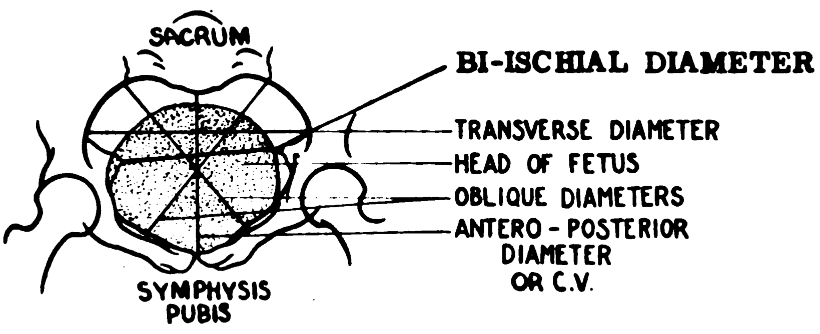


PELVIS, OBSTETRICAL, AXIAL



Adjustable support to obtain Thom's measurements.

The essential measurements to be taken are indicated in the diagram below.



Approximate normals are about as follows:

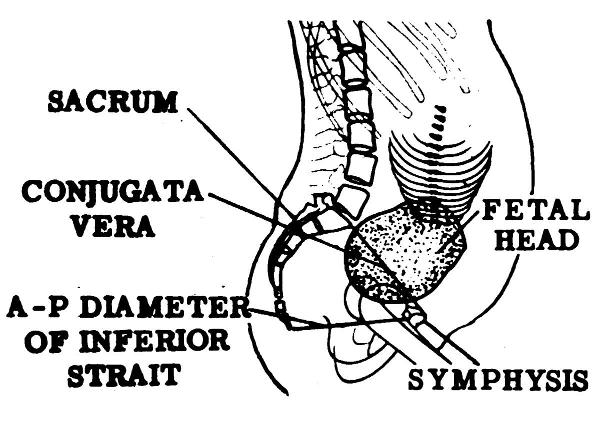
Antero posterior diameter–Conjugata vera or	C.V.	12.5	Cms.
	Obliques	13	"
	Trans. Dia.	13	"
	Bi-ischial Dia.	11	"

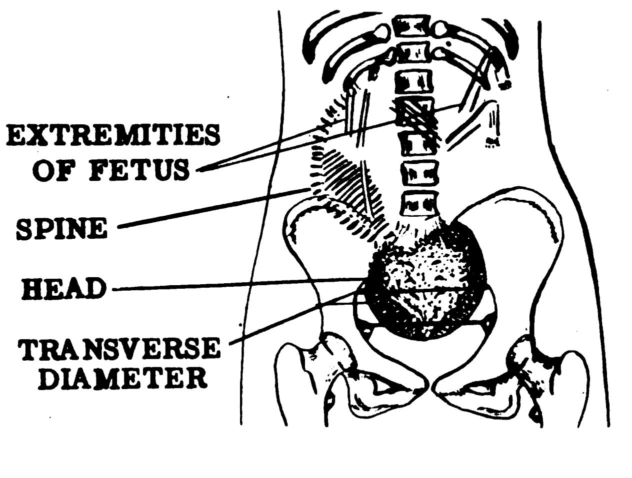
The foetal head is usually 10 - 12 cms. in length (occipito-frontal) and 8 - 10 cms. in breadth (bitemporal). Its measurements are subject to more uncertainty than the pelvic as the height of the head above the plate varies. Thus the accuracy of foetal head measurements should be discounted somewhat.

(3) Obstetrical Pelvis, Early Pregnancy:

When views for the determination of the presence of early pregnancy or possibly for determination of the probable age of the foetus are desired, the patient is placed in supine position with the pelvis over the Bucky. Centering is over the lower abdomen usually higher than the level of the anterior superior spine of the ilium and the central ray is vertical.

The bones of the foetal skeleton become visible late in the third month or early in the fourth. The following table will help in the determination of foetal age. Compression and sharp coning plus the use of the Bucky may be needed to get the requisite fine detail, in early months.





Comparison of Fetal Age, Weight, Dimensions of Skull, and Length of Calcified Portion of Femur.

Fetal age in lunar months	Weight in grams	Biparietal diameter in cm.	Occipitofrontal diameter in cm.	Mean circumference in cm.	Shaft of femur in cm.
3	12	1.0	2.0	5.5	0.5
4	90	2.5	4.0	11.0	2.0
5	250	4.0	6.0	15.5	3.0
6	800	5.5	7.0	19.5	4.0
7	1050	6.5	8.5	23.5	5.0
8	1550	7.5	10.0	27.0	6.0
9	2250	8.5	11.0	30.0	6.5
10	3250	9.5	12.0	33.0	7.5

Uterosalpingogram:

This simply involves views of the pelvis following injection of a radio-opaque fluid, usually some type of iodized oil such as lipiodal, into the uterine cavity. Visualization of the uterus and Fallopian Tubes is sought. The injection is usually performed by the gynecologist, occasionally with the aid of the roentgenologist and under fluoroscopic control.

For radiography the patient is placed in supine position with the pelvis over the Bucky. The X-ray is centered vertically over the suprapubic region. Stereoscopic views are often desired.

Miscellaneous:

Myelograms:

The purpose of the myelogram is to visualize the spinal canal with the idea of demonstrating defects in its contour occasioned by such pathological conditions such as protrusion of the intervertebral discs (Herniation of the Nucleus pulposus), thickening of the ligamentous structures (Ligamentum flavum) and tumors. To obtain the necessary contrast air may be used (aerogram) or iodized oil. The latter affords much better differentiation but most of these products are irritating. A newer type is now beginning to come into use, which is of thinner consistency, and more readily removed and is absorbed. (Pantopaque).

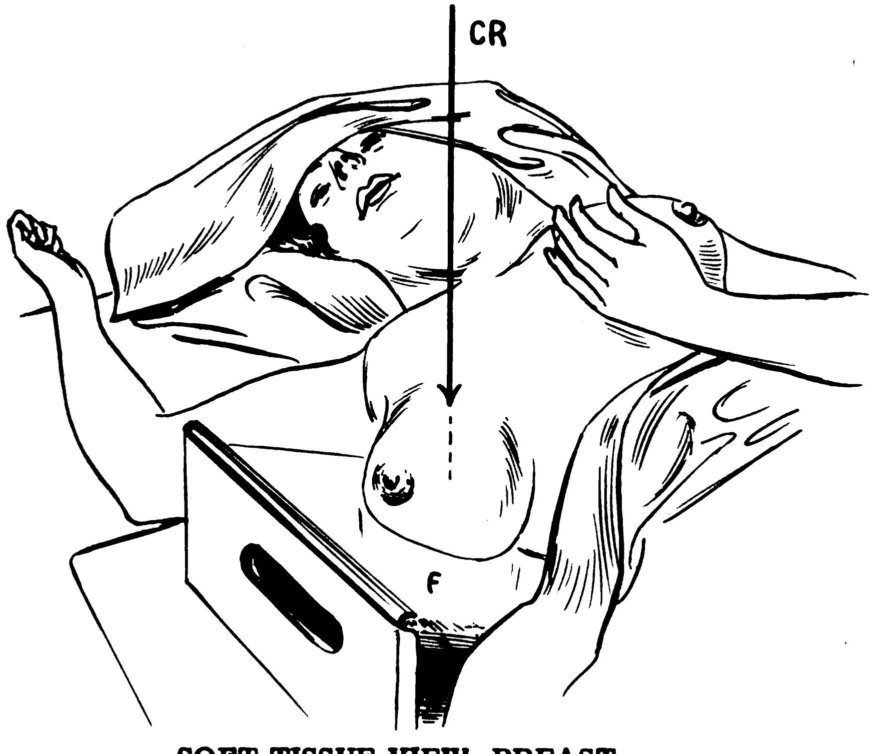
When air is used, the patient is placed on the table with the head end much lower than the other. Thus a tilting table is necessary. Views are taken in the A.P. and Lateral positions using the usual lumbar spine technique. (Most lesions are in the lumbar and the utility of aerograms is mainly limited to that region).

When lipiodal or other iodized oil is used the oil will be heavier than the spinal fluid and thus will flow in accordance with gravity. The patient, after injection, is examined under the fluoroscope as the table is tilted up and down. The most useful positions are prone and lateral. This is because herniated discs project posteriorly ~~from~~ into the anterior portion of the spinal canal and so are best noted as a column of iodized oil, not too thick, passes along the canal. Shows a defect in contour where it

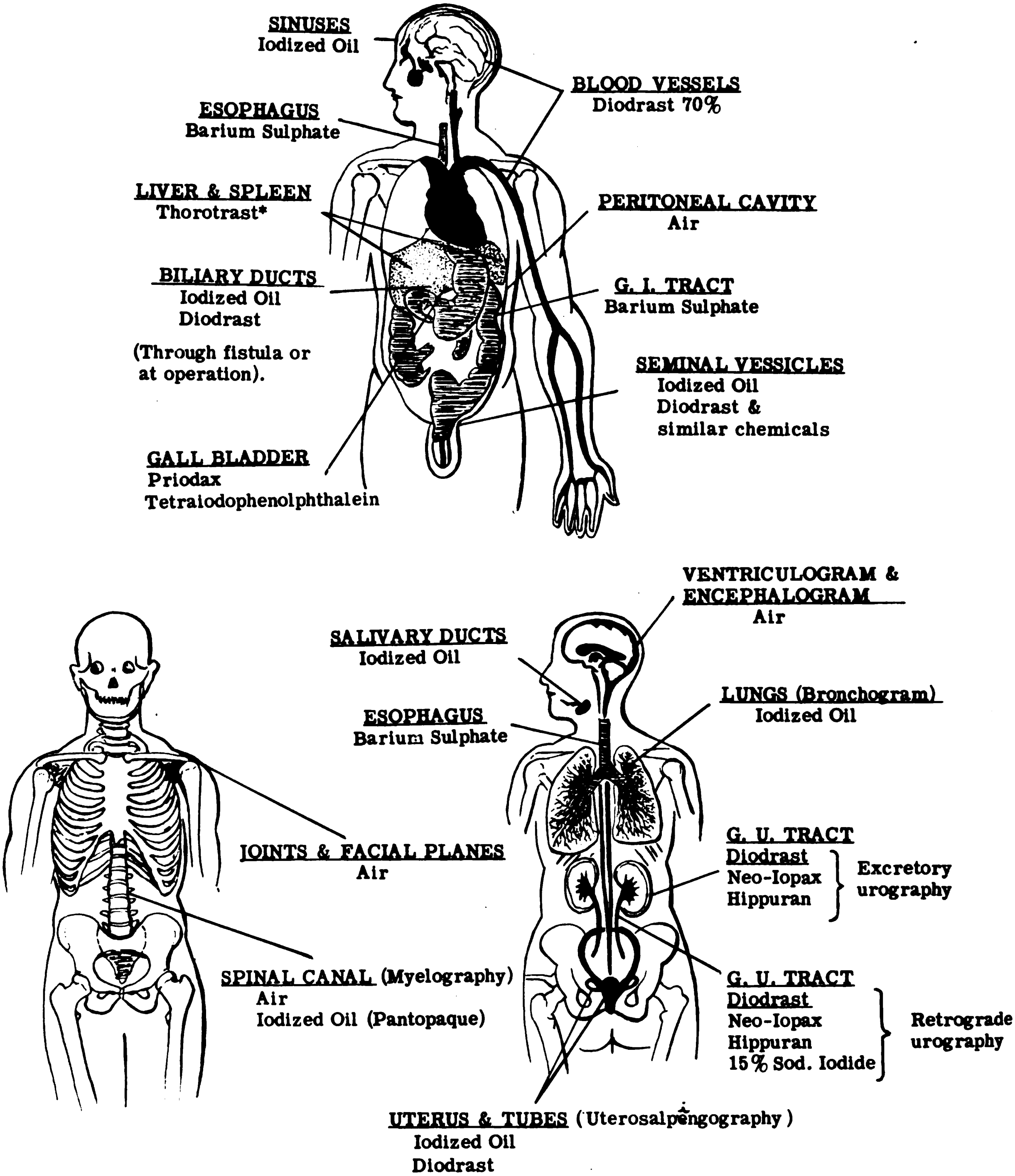
meets the bulge). Spot films should be made whenever suspicious findings are encountered. These spot film views will require more exposure than the spot films of the gastro-intestinal films. About 0.6 to 0.8 seconds, 100 M.A. at 70 to 85 K.V. P.,will usually do. If spot films cannot be made, the motion of the table can be halted whenever conditions are promising and a regular radiograph made with the tube above the table. If the fluoroscopic assembly does not permit of either, one can only try to repeat the position on the radiographic table and hope that fortune will be kind. Technique for myelograms following use of iodized oil is the same as for regular views of the spine.

Breast:

Both sides should always be taken. The patient is placed in the lateral recumbent position so that the lower breast rests on the cassette or Bucky table. Some recommend that the breast rest on an angle board (17 - 23 degrees). The lower arm is extended or may be placed under the head. The patient should lift the upper breast out of the radiographic field by the upper hand. The X-ray is centered near the base of the breast, and is vertical. There is a wide choice of radiographic techniques. One of the best is the 300 M.A.S. technique used with double screens, low voltage (about 30 K.V.P.) and 39-40 inch distance. The current is usually 100 M.A. for 3 seconds. Another method is, as noted in charts, to employ screen technique with 8 less than the regular thickness of part K.V.P. Non-screen film may be tried at about 50 K.V.P., 50 M.A.S. and 30 inch distance. Bucky exposures with reduced voltage will also give good results; likewise, anterior oblique chest films will visualize the breasts to good advantage. The technique for regular oblique chest films can be followed.



SOFT TISSUE VIEW, BREAST


SINUSES
Iodized Oil
BLOOD VESSELS
Diodrast 70%
ESOPHAGUS
Barium Sulphate
LIVER & SPLEEN
Thorotrast*
PERITONEAL CAVITY
Air
BILIARY DUCTS
Iodized Oil
Diodrast
(Through fistula or at operation).
G. I. TRACT
Barium Sulphate
SEMINAL VESSICLES
Iodized Oil
Diodrast & similar chemicals
GALL BLADDER
Priodax
Tetraiodophenolphthalein
VENTRICULOGRAM & ENCEPHALOGRAM
Air
SALIVARY DUCTS
Iodized Oil
ESOPHAGUS
Barium Sulphate
LUNGS (Bronchogram)
Iodized Oil
G. U. TRACT
Diodrast
Neo-Iopax
Hippuran
Excretory urography
JOINTS & FACIAL PLANES
Air
SPINAL CANAL (Myelography)
Air
Iodized Oil (Pantopaque)
G. U. TRACT
Diodrast
Neo-Iopax
Hippuran
15% Sod. Iodide
Retrograde urography
UTERUS & TUBES (Uterosalpingography)
Iodized Oil
Diodrast

CONTRAST MEDIA AND THEIR APPLICATIONS

Since the soft tissues do not differ very markedly in density, radiographs fail to visualize with clarity such structure as the urinary tract, gastro-intestinal tract, gall bladder, etc. Accordingly a number of contrast media are employed.

Barium Sulphate:

This is a fine white powder, entirely inert and used for examination of the stomach and intestines. It is suspended in water usually with the aid of acacia to make mixtures of various consistencies depending upon the part to be examined and the type of examination.

For the esophagus a thick mixture is usually desired. A teaspoonful of acacia added to a few ounces of water and followed by sufficient barium sulphate to make a fairly thick paste will answer. The addition of several teaspoonfuls of malted milk and a few drops of vanilla will render the mixture less distasteful and lessen the tendency to nausea.

For examination of the stomach and intestinal tract, usually spoken of as the gastro-intestinal or G.I. Series, about 3 - 4 oz. of barium is mixed into enough water to fill the regular full sized drinking glass. A teaspoon of acacia dissolved before the addition of barium, should also be used. Malted milk and a little vanilla will again make for greater pleasantness, although such is commonly dispensed with. Some workers believe it may affect motility to an undesirable extent. This type of mixture will also answer for serial studies of the small intestines and for views of the colon by ingested barium. Cool water is best.

For the barium enema several teaspoonfuls of acacia and 6 - 8 oz. of barium sulphate are mixed into warm water and the volume made up to 1-1/2 to 2 qts.

An electric mixer is a great convenience in a busy department.

Routine of the Gastro-intestinal series:

This varies greatly in different institutions and the following is mentioned only as an acceptable type in frequent use.

(1) Preparation: The patient takes a mild laxative the night before. Milk of magnesia is a favorite; castor oil is sometimes called for. Sometimes a cleansing enema is prescribed for the next morning. The above are largely optional. The essential feature of preparation is simply that the patient abstain from food or drink for at least six hours before the examination. A good rule is: "NOTHING BY MOUTH AFTER MIDNIGHT".

(2) Examination: This consists of both fluoroscopic and radiographic procedures and is usually scheduled at from 8:30 to 10:30 in the morning. The number and type of radiographs are designated by the roentgenologist, and the points for centering, marked. Most commonly a few immediate views are taken and the examination of the upper intestinal tract is completed. Quite often, a view of the colon will

be desired. In such case a 24 hour film is usually ordered and the patient told to avoid laxatives and take no enemas until after that view is taken. When serial views of the small intestine are desired, the roentgenologist will ordinarily prescribe the times at which they are to be taken. Often, these times will be about as follows: Immediate, 15 min., 30 min., 1 hr., 2 hr., 4 hr., and 6 hr.

For gastric relief (mucosal pattern), pressure views are usually made after one or two swallows of barium. The spot film device answers best for this.

When views of the esophagus are desired they should be taken in the right anterior oblique position 1 - 3 or possibly more seconds after the patient swallows some barium suspension. The patient is properly positioned, given some barium and instructed to hold it in his mouth until the technician is ready to make the exposure. By proper management, this time should be very short. The patient then swallows and the exposure is made.

It might be noted here that an excellent way to determine the actual width of the aorta is to take a P.A. Projection of the chest immediately after the patient swallows barium. The barium filled esophagus outlines the medial border of the aorta. The lateral border, at the arch, extends to the left of the spine and so is easily distinguished. The chest exposure should be considerably heavier than in the case of the conventional chest view.

Caution: In cases of suspected intestinal obstruction the use of barium sulphate is attended with danger. This should be taken into account and if it is decided that in any particular case the possible risk is justified some special precautions can be used. The amount of barium can often be sharply reduced. The addition to the suspension of some mineral oil emulsion will aid in preventing the aggravation of the possible obstruction. If it turns out that the obstruction is high it may be possible to withdraw much of the barium by the duodenal or other type of tube.

Routine of the Barium Enema:

(1) Preparation: The patient is prepared by cleansing enemas. In many cases a single enema in the morning will suffice. However, where constipation is present, an enema on the preceding night as well as in the morning is advisable.

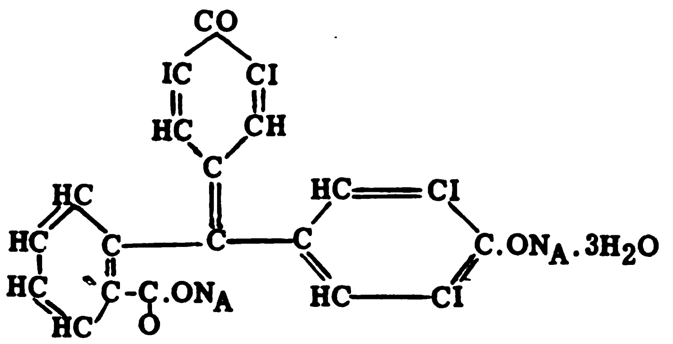
(2) Examination: The colon is gradually filled under fluoroscopic observation. Some patience may be needed in order to obtain complete filling. Spasm may result from too rapid flow and produce simulation of an organic obstructive lesion. Be sure that attendants know precisely what they are to do. It happens not infrequently, that an inexperienced nurse left alone to insert the enema tube, will blandly proceed to fill the colon with the barium suspension before summoning the roentgenologist. Gentle massage of the colon will help the filling process, as well as aid in determining pathological features. Spot films will be desired at times. It is good practice to obtain filling of the terminal ileum whenever possible. The routine radiographic views consist of a view immediately after completion of the enema and another after evacuation. The patient should be instructed to evacuate as much as possible of the barium and should be given ample time to accomplish this. When evacuation is thorough, excellent visualization of the mucosal pattern is usually obtained.

At times a "double contrast" examination is desired. To accomplish this, air is injected into the colon either by a hydrostatic device, or a bulb insufflator, after evacuation of the barium. (Sometimes aids in detecting polyps).

Gall Bladder Visualization (Cholecystogram or Graham-Cole Test):

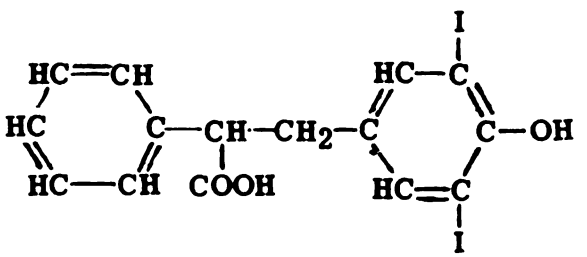
Visualization of the gall bladder depends upon providing a non-toxic, absorbable substance of high atomic weight which will be excreted by the liver in the bile.

Compounds of iodine have proven best for the purpose and tetraiodophenolphthalein has been the preparation of choice for a number of years.



Tetraiodophenolphthalein, $C_{20}H_8O_4Na_2I_4.3H_2O$

At present a new compound called "Priodax", is coming into use.



"Priodax" Beta-(4-hydroxy-3,5-diiodophenyl)-alpha-phenyl-propionic acid $C_{15}H_{12}O_3I_2$

In the case of tetraiodophenolphthalein, many commercial preparations are on the market and go by trade names such as "Shadocol", "Keraphen", and "Stipolac". The essential chemical is the same in all cases. They are quite convenient for ready use and some brand is usually available in the Naval Supply Depots for requisition. However, it is quite possible to use the chemical itself as purchased from a drug house. Directions for using commercial preparations should be followed meticulously.

The dye may be given intravenously or orally, but the latter method is almost invariably used. The intravenous method is employed only in special cases usually when the results from oral administration are inconclusive.

The commercial preparations are usually simply added to a half glass of water and stirred until the solution becomes "milky" before the patient takes it. If the chemical itself is to be used, proceed as follows:

Dissolve 7 grams of the dye in an ounce of water. This is usually taken in two separate doses as follows: One half of the solution just prepared is stirred into a glass of grape juice and,when thoroughly mixed,taken by the patient. When it is time for the second dose, the other half of the dye solution is added to grape juice, stirred well and taken. If only a single dose is to be taken, dissolve 4 - 5 gms. of the dye in an ounce of water and add to a glass of grape juice, or plain water may be used.

For intravenous use: (1) Dissolve 2.5 to 3.5 gms. of tetraiodophenolphthalein in 20 - 30 cc. of freshly distilled water - preferably sterilized, and at a temperature close to boiling. A small Ehrlenmeyer flask is convenient for the purpose. (2) Heat 15 minutes in boiling water bath. (3) Allow to cool. It is then ready for injection. This is best done at about 5:00 P.M. the evening before X-ray studies are to be made. Injection should be done very slowly as the dye has a pronounced irritating effect on the veins and will readily produce thrombosis.

Filtering may be done but is not necessary.

Ampules of the drug may be obtained and are quite convenient.

Naturally the preparations specially designed for oral use are absolutely unsuitable for intravenous use.

In cases of jaundice the Gall Bladder seldom visualizes and the Graham-Cole test is not often of value. Occasionally, however, it may be advisable. In that event there need be no fear of harmful effects unless the liver is very severely damaged as would be indicated by a very low value for cholesterol esters in the blood (40 or less), a galactose excretion of 3 or more grams in the galactose tolerance test or the presence of tyrosine in the urine.

The chemical with the trade name "Priodax",mentioned above as now coming into use, is administered orally only and in tablet form instead of liquid. Otherwise, the general procedure is the same as with the phenolphthalein derivative. A single half gram (0.5 gm.) tablet is swallowed every 5 minutes until 6 are taken (3.0 gm.). Or, if the dose is to be proportioned to weight, one tablet is taken for each 25 lbs. weight.

The time of ingesting the tablets is the same as for drinking the other preparation and either the single or double dose method may be employed; in the latter instance 6 tablets are taken on each occasion.

Toxic reactions have not been noted and it appears that there is less tendency to nausea and diarrhea than with the older preparations.

ROUTINE GRAHAM-COLE TEST:

A preliminary film of the abdomen before administration of gall bladder preparations is an excellent measure.

Oral method, double dose: Various routines are in use but the "double oral" method is one of the best. A direction sheet such as the one below should be given the patient along with the Gall Bladder "dye" - either two (3.5 or 4 gram) bottles of tetraiodophenolphthalein or the proper number of Priodax tablets (usually two boxes of 6).

PREPARATION FOR X-RAY VISUALIZATION OF THE GALL BLADDER.

A. PRELIMINARY:

(1) Make appointment well in advance whenever possible.
(2) The intestinal tract should be clear. If there is a tendency to constipation take a laxative the day before taking the dye. Castor oil and compound licorice powder are excellent; also sodium phosphate or magnesium sulphate.
(3) Be sure to obtain two (2) bottles of Gall Bladder dye or 2 boxes of Priodax tablets.

B. DAY BEFORE EXAMINATION: (X-RAY).

(1) Regular breakfast and noon meal permitted; no restrictions.
(2)(a) Immediately following noon meal stir one (1) bottle of dye in half glass of water and let stand until it turns milky (5-10 min.). Then drink mixture.
(b). Or, take one Priodax tablet every five minutes, with a few swallows of water, until six are taken.
(3) During the afternoon restrict activity and rest if possible. Water may be taken. If stomach feels very upset one or two teaspoons of PAREGORIC in a little water may be taken.
(4) Evening meal must be fat free and should be taken at about 6 P.M. (No milk, cream, mayonnaise, salad dressing, butter, gravies, etc.).
(5) Prepare remaining bottle of dye as before and drink immediately after the meal; or take six Priodax tablets in the manner described above.
(6) No further meals are to be taken. Restricted activity advisable. Water may be taken or orange juice. PAREGORIC may be repeated, especially if severe purging develops.

C. DAY OF X-RAY EXAMINATION:

(1) No regular breakfast is permissible. However, orange juice,tea or coffee without cream or milk may be taken and also toast or crackers without butter.
(2) Report to X-ray Department at 8:30 - 9:00 A.M. and be prepared to remain several hours.

N.B. List of foods which may be used for a fat-free meal:

Tea or coffee without cream or milk.
Fruits and fruit juices but no avocados or nuts.
Vegetables, if cooked in plain salted water. (No bacon, salt pork or other meats to be cooked with them).
Salads, minus any oil dressing or mayonnaise.
Toast and crackers with jelly as desired; (no cakes or muffins).
Clear broth if meticulously skimmed and showing no fat globules.

RADIOLOGICAL PROCEDURE:

First of all remember that patients occasionally fail to retain the dye and will state that they have vomited all of it. The films should be made just the same. In many cases, a large amount of dye will have been absorbed before vomiting occurs and good visualization will be obtained.

One or two films are made and inspected as soon as they are cleared. This should be done immediately upon arrival of the patient in the morning. These will determine if satisfactory visualization is present.

If the contents of the hepatic flexure obscure the gall bladder region an enema is advisable or the medical officer may give an injection of petressin. If the gall bladder is poorly centered or the technique of exposure wrong the views will indicate what is necessary for correction. If the gall bladder fails to visualize the examination is often terminated.

However, it is safer to repeat the view in an hour and then proceed with the fatty meal and the remainder of the examination, as at times there is delayed visualization. It is also well to extend the time for the final film several hours beyond the fatty meal, if no gall bladder shadow has been produced - particularly in repeat examinations.

Usually satisfactory films of the gall bladder are obtained upon the first examination and the patient is then given a fatty meal consisting of a glass of milk and cream, equal amounts, and a sandwich containing bacon and some mayonnaise. An hour later another view is made. The gall bladder is normally considerably smaller in this view.

This film usually terminates the series. It might be noted that some routines call for thirty (30) minute films; others may call for films several hours after the fatty meal.

Oral Method, single dose: When this technique is employed, the gall bladder dye is usually given immediately after the evening meal which again must be fat free. Thus the procedure remains the same except for the omission of the earlier dose of the gall bladder preparation.

Intravenous Method: As noted above, injection is carried out the evening before, usually at 5:00 P.M.

Following this the patient may have water or sweetened orange juice but no other food until the first films are made the next day. These are made at about 8:30 - 9:00 A.M. and the procedure thereafter is the same as for the oral method.

Note: In cases where the gall bladder fails to visualize it is common practice to have the examination repeated. Such repeat examinations should be conducted with special attention to possible variation in procedure as described above.

Contrast Media for the Urinary Tract:

These include media for visualization by intravenous injection and by direct injection into that tract.

The first method is spoken of as intravenous pyelography or excretion urography. The second is called retrograde pyelography.

The substances used for intravenous injection are complex iodine derivatives furnished in ampules containing the required amount in solution form (usually 20 cc.). This same substance can be used for retrograde pyelography with excellent results. It is quite unirritating. Sodium iodide may also be used for retrograde pyelography but not for intravenous visualization. It is used in about 15% solution for direct injection into the urinary tract. It is more irritating than the other media.

Routine for intravenous pyelography:

Preparation: This is often omitted but better work will result if the gastro-intestinal tract is cleared out by use of castor oil or compound licorice powder the day before. In addition, dehydration by the withholding of fluid for 8 - 10 hours prior to examination will aid in producing denser shadows.

PYELOGRAM

CYSTOGRAM

Examination: The urographic dye is injected intravenously and views are made at various intervals as ordered by the medical officer. If injection has been rapid the first film is made after 5 minutes, and a second in 10 or 15 minutes. If injection has been slow, the first view is made in 10 or 15 minutes and the second 10 minutes later. Subsequent views may or may not be necessary. However, it is a frequent practice to follow the first two views by a film with the patient upright to determine the matter of ptosis. The views are usually the regular A.P. projections made with the X-ray centered at about the level of the iliac crests. With large individuals additional views for the bladder may be required. Oblique or lateral views are not made unless directed by the urologist or roentgenologist. The use of the Trendelenburg position or of a compression bag over the lower abdomen following injection will often improve the delineation of the pelves and calices of the kidneys.

Tests for undue sensitivity to iodine are becoming a routine preliminary precaution as on rare occasions a patient has been seriously affected by the intravenous use of the various substances used. The usual test is to inject about 1/15 to 1/10 cc. of the particular preparation to be used intradermally about 15 minutes before proceeding. Sensitivity is, of course, indicated by reaction, usually in the form of a large wheal.

Names of several of the preparations used are: Diodrast, Iopax, Neo-iopax and Hippuran.

Retrograde pyelography:

This is, of course, only possible following cystoscopy and catheterization of the ureters. Accordingly the views made are in accordance with the instructions of the urologist. They are usually the conventional A.P. projections supplemented by occasional special views. As noted above either an intravenous preparation is used or sodium iodide solution.

Cystograms: For visualization of the bladder either of the above noted preparations may be used or air. As part of the studies made in connection with excretion or retrograde pyelograms the bladder is usually shown in the A.P. projection. When the bladder is the only part under consideration or the main one, simple injection of a contrast medium through a catheter will answer. Views are then usually called for in oblique and lateral projections. Centering is over the lower abdomen and no special problems not already considered are involved as regards radiography.

For visualization of the seminal vesicles, iodized oil is occasionally used. The 20 degree angle view of the bladder will answer. Stereoscopic films will probably be a help.

Miscellaneous:

In addition to the above listed procedures involving contrast media, which are in constant use, there are a number to mention briefly.

Air or other gas is sometimes injected to outline:

(a) Fascial planes in the muscular tissues.
(b) Structures in the knee joints.
(c) Uterus and Fallopian tubes (to determine patency).
(d) Kidneys (by injection into the perirenal tissues).
(e) Peritoneal cavity.
(f) Pleural cavity (to outline pleura and also for therapeutic purposes).

In review it might be noted that the routine uses are for cystograms, encephalograms, ventriculograms, and double contrast studies of the colon.

Barium sulphate is sometimes used for injecting draining sinuses as well as for gastro-intestinal studies, although iodized oil is usually preferred.

Bismuth salts are also used for injecting sinus tracts. In fact, quite a few substances have been used to render sinus tracts visable, such as iodides, iodoform, thorium salts and silver preparations.

Iodized oil is also used for visualization of:

(a) Nasal accessory sinuses.
(b) Salivary ducts.
(c) Trachea and bronchi.
(d) Bile Ducts either through a post-operative drainage tube (or fistulous opening) or by injection into the common duct during operation.

Its use in myelography, etc. has already been described. Remember that a product is becoming available which is a great improvement over the heavier preparations such as lipiodal, lipiodine, iodipin and also the bromine preparations which are sometimes used. The name of the newer preparation is "Pantopaque".

Organic iodine compounds such as are used for urography are also used for:

(a) Visualization of the bile ducts, substituting for iodized oil.
(b) Visualization of blood vessels. A highly concentrated solution of diodrast is being tried for this purpose.
(c) Injection of draining sinus tracts.

It might be noted that one preparation of this type called "Hippuran" has been tried with some success for the production of excretion urograms after oral administration.

Thorium Dioxide in Colloidal solution (Thorotrast) has been used for visualization of sinus tracts, blood vessels and also the liver and spleen. The latter is made possible by the fact that these organs (liver and spleen) will retain the bulk of any thorium that has been injected or absorbed into the circulatory system. The question of ultimate damage to the liver by the retained thorium has not been definitely settled and so its use is not regarded with much favor as yet.

QUESTIONS:

1. Describe technique for:
    (a) axial view of os calcis.
    (b) intercondylar view of the knee.
    (c) lateral view of the femoral neck.
    (d) view of lumbo-sacral articulation.
    (e) lateral view of the cervical spine.
    (f) left anterior oblique of the chest.
    (g) P.A. projection of the Gall bladder.
    (h) "spot shot" of the stomach.
    (i) axial view of the obstetrical pelvis.
    (j) views of the oesophagus.

2. Describe two methods of visualizing the mastoid. Describe the Stenver's position.

3. Describe four views of the sinuses which will comprise a satisfactory set.

4. What means would you adopt to insure good visualization of the carpal navicular?

5. List principal contrast media and state their application.

6. How would you prepare mixture for barium enema?

7. Describe a satisfactory routine for Graham-Cole test, oral method.

8. Define Encephalogram, Ventriculogram, myelogram, urogram, excretion urography, retrograde pyelogram, cystogram.

9. Give the names and the corresponding numerical designations of the teeth.

10. Describe a radiographic technique for the sternum; lateral view of the upper dorsal spine.

11. What is the purpose of Thom's measurements? Describe radiographic technique for obtaining these measurements.

12. State the nature and purpose of the following: Diodrast; Camp localizer; Priodax; Pantopaque.

13. Describe two methods for obtaining soft tissue films.

NOTES ON SPECIAL PROCEDURES

Fluoroscopy:

It will probably appear far fetched to most workers to list fluoroscopy under special procedures, since it is in constant use and seems an old familiar friend. The fact is that it is perhaps all too familiar and we all tend to forget that it presents insidious dangers. The fluoroscopist, intent upon his examination fails to remember tolerances and safety factors. Moreover numerous physicians, untrained in roentgenology, are using fluoroscopes in lung clinics, cardiac examinations and orthopedic work. In the nature of things these individuals are not apt to be fully acquainted with the dangerous possibilities of this method of diagnosis. The following precautions should be religiously observed especially when one is performing fluoroscopy regularly.

1. Obtain a high degree of dark adaptation before attempting work. Otherwise, not only will you fail to see all you should, but will be tempted to call for heavier X-ray factors. It is usually recommended that dark goggles be worn for five minutes or that the same period of time be spent in a totally darkened or very dimly lighted room. This is not enough except where gross and well contrasting outlines are involved. For good visualization of detail, 20 to 30 minutes of preparation are essential. Both green and red goggles are available for the purpose but red appears preferable since it leaves the eyes better sensitized to the greenish light of the fluoroscopic screen. The goggles now used for accomodation of the eyes to night flying are excellent. When light is brilliant, preliminary use of ordinary sun glasses is helpful. Vitamin "A" deficiency is to be remembered as a possible factor if dark adaptation is poor.

2. Use moderate current. 3 - 4 M.A. will answer general fluoroscopic needs, at about 75 K.V.P. An increase to 85 K.V.P. will give sufficient penetration for most stout people without any increase in M.A.

3. Keep a "light foot" on the switch. That is to say that exposures should be intermittent. Flashes of from 4 - 8 seconds followed by equally long or longer "off" periods should be the rule.

4. A large field is needed only for very brief periods. The greatest part of ones work will be benefited by reducing the X-ray field to the smallest possible size. This improves definition and also cuts down the exposure inflicted both upon the patient and the operator. Hence the rule: "Keep the X-ray beam small".

5. Keep the hands out of the direct X-ray beam. This is one of the most important rules. It is most apt to be disregarded in attempted reduction of fractures and dislocations under fluoroscopic control. If the hands are invariably kept in front of the patient so that he acts as a screen or filter, very few damaging rays will reach them. However, this is not always easy to manage. Accordingly the best rule is: "Always wear leaded gloves". If for some special purpose the usual heavy glove cannot be used, even a light glove will afford some protection from the soft and most damaging rays.

6. 1 mm. Aluminum filtration should always be present. In the case of oil-

immersed tubes there is usually inherent filtration of 1/2 mm. Al. so that with these tubes the addition of a 1/2 mm. Al. filter will suffice.

7. Use lead rubber aprons if any considerable amount of work is done.

8. Make occasional tests for excessive radiation exposure by placing dental films, bearing a paper clip, in several pockets. After two weeks develope the films. If a clear image of the paper clip is obtained there has been too much exposure and better protective measures should be taken.

9. If the lead glass on the fluoroscopic screen becomes cracked or broken, have it replaced at once.

10. Use of an ordinary intensifying screen is possible when regular fluoroscopic equipment is lacking. Remember, however, that there will be no lead glass protection and that accordingly the operator is certain to be dangerously exposed. Therefore, such use of an intensifying screen is justifiable only on a real emergency basis.

11. Bear in mind the total exposure limits for the patient.

12. Have a blood count made every quarter. A low W.B.C. is the first indication of excessive exposure. If exposure is heavy, do this oftener.

13. Maintain good ventilation in the fluoroscopic room.

14. It is a good plan to post a list of the more important precautions on the fluoroscope, particularly if used by people relatively untrained in roentgenology. A sample list is as follows:

NOTICE

Use of Fluoroscopic Equipment

1. Fluoroscopic equipment is a source of great danger to all concerned unless safe methods and exposure factors are used. Further, the machine itself can easily be damaged.

2. Do not operate this machine unless you are familiar with its operation in all respects. No unauthorized person should tamper with it.

3. In case of trouble or uncertainty notify the X-ray Department.

4. Fluoroscopy calls for: (a) proper accommodation of the eyes ~~(5-10 min.)~~; (b) a current of about 75 K.V.P. and 3 M.A.; (c) brief and intermittent exposures; (d) operator's hand out of the direct beam of X-ray; (e) target-skin distance not less than 12 inches; (f) aluminum filter (1 mm.).

Safe limits at 12 inches for 3 M.A. with 1 mm. Al. Filter

Head: 575 M.A.S. or total of 3 minutes and 12 seconds of actual exposure at 3 M.A.

Other parts: 768 M.A.S. or 4 minutes and 16 seconds of actual exposure at 3 M.A.

15. Finally it is to be remembered that, with certain obvious exceptions, fluoroscopy is a poor and dangerous substitute for radiography.

Fluoroscopic apparatus:

Fluoroscopy depends, of course, on the fluorescent images produced on a screen coated with materials similar to those used on intensifying screens. The screen is covered by lead glass. This protects the screen from dirt, etc. It also protects the fluoroscopist from the direct radiation which would otherwise strike his face. It does not, however, protect the screen from light. Thus the screen should be covered with black cloth when not in use, as light gradually causes deterioration. Care should be exercised to prevent the spilling of diagnostic opaques or other material on the screen assembly. Some may find its way to the screen proper and damage it.

The tubes used on fluoroscopic machines do not have unlimited capacity. Thus there is another reason aside from excessive exposure for sparing use. This is apt to be of particular importance in war time. In many places, replacement of burned-out tubes will be difficult and subject to disastrous delay.

For chest and heart work a simple upright machine will answer well. For most other kinds of work, a tilting model, preferably one that will tilt to the Trendelenburg position, is necessary.

STEREOSCOPY:

This procedure, as anyone who is familiar with the old fashioned stereopticon will know, is designed to give accurate depth perception. Depth perception, in ordinary vision depends on binocular vision, that is, the use of both eyes. A single radiograph corresponds to vision with one eye and to the ordinary photograph. Stereoscopic radiographs correspond to vision with both eyes and the stereoscopic photograph.

To obtain the stereo effect in radiography two films are made, the X-ray tube being shifted the interpupillary distance (about 2-1/2 inches) between each view, when the target or anode film distance is about 25 inches. When the target-film distance is greater the tube shift will have to be increased in order to prevent undue distortion of the resultant stereoscopic image. The rule is to use a tube shift of about 1/10th the anode-film distance. Thus if stereoscopic chest films at 72 inch anode-film distance are desired, the tube shift should be slightly over 7 inches. The patient should not change position between views and the second cassette should be placed in exactly the same position as the first. When close precision is needed the

viewing distance on the stereoscope must be taken into account as this too affects the amount the tube should be shifted. An accurate table is as follows:

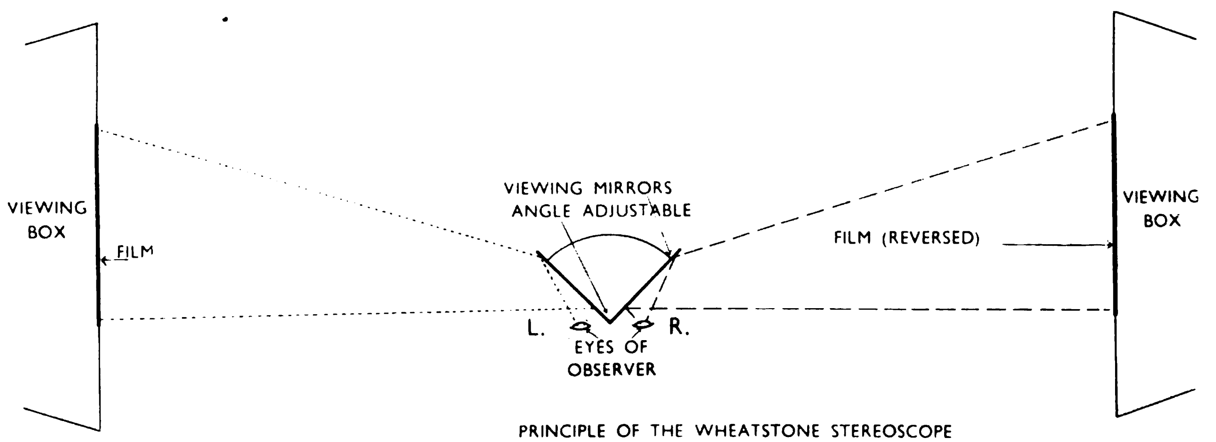
Relation of Various Stereoscopic Factors

Anode Film Distance	Tube Shifts for Viewing Distances on Stereo Illuminators		
	25 inches	28 inches	30 inches
25 inches	2-9/16 inches	2-1/4 inches	2-1/16 inches
30 "	3-3/16 "	2-3/4 "	2-9/16 "
36 "	3-7/8 "	3-3/8 "	3-1/8 "
48 "	5-3/8 "	4-11/16 "	4-5/16 "
72 "	8-5/16 "	7-1/4 "	6-11/16 "

It should always be remembered that any errors in making stereoscopic views will result in distortion of the resultant image as visualized in the stereoscope. Gross errors will result in such bizarre effects as the illusion of certain internal structures being outside the body. Needless to say distortion defeats the primary purpose of stereoscopy.

To view the stereoscopic films a mirror apparatus is used. The type most frequently found is the "Wheatstone" stereo: Two illuminators are mounted facing each other on a supporting frame that permits of the illuminators moving to and fro in such manner that they are always equidistant from a central point in which two plane mirrors are set at about a 45 degree angle, apex toward the observer. Blinders are attached to each mirror so that when the observer's eyes are brought close to the mirrors he will see only what is reflected from the mirrors, each mirror reflecting its image into the eye in front of it. When a pair of matched films is placed in the illuminators the result will be that the observer will "see" a single image in front of him. If the films are identical the image will be flat. If they form a stereoscopic pair the depth effect will be present. In order to provide adjustment for the varying conditions pertaining both to exposure technique and differences in the eyes of observers the mirrors are arranged so that their angle can be varied, the lateral tilt varied and the whole mirror assembly moved back and forth.

Thus it is possible for any person to obtain a precise adjustment to his eyes. If a person has a defective optical fusion center in the brain, then of course he will never find stereoscopy profitable.



PRINCIPLE OF THE WHEATSTONE STEREOSCOPE

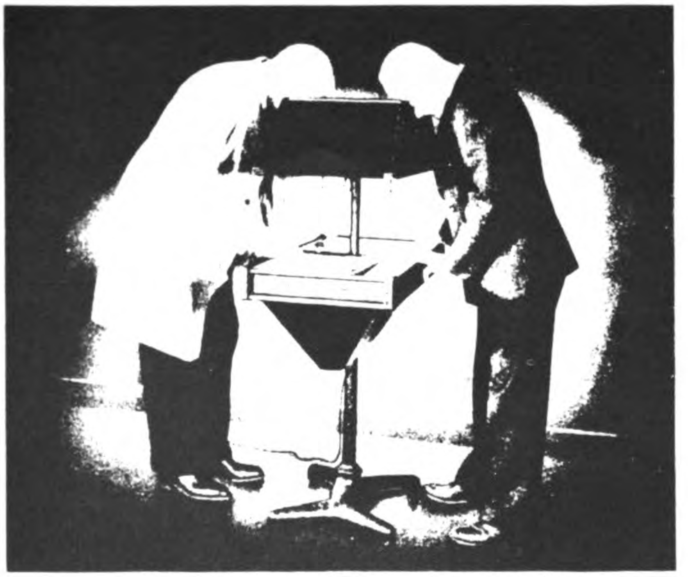
There are numerous ways of placing the films in the stereo so that a stereo effect is obtained. There is, however, only one truly correct way. In this, the view of the patient obtained should be that which would result if one could place the eyes in the two positions of the anode of the X-ray tube and observe the patient with X-ray vision.

To obtain this result one can, of course, resort to trial and error. Certain rules will, however, save much time. These are: (1) Superimpose the films with the tube sides away (i.e., reversed); (2) Adjust so that the displacement of the images is horizontal; (3) The film whose image is nearest the right hand is placed in the right hand view box; the other is placed in the left box. Naturally the reverse side of the films faces the mirror as this compensates for the mirror effect which, as should be well known, is that of reversal.

In order to facilitate this procedure the film marker should always be placed face up. In addition, it is a good idea to place the marker on top of the Bucky table or plate tunnel instead on top of the cassette itself. Then the marker will register in the same plane as the lowermost portion of the part radiographed. An arrow to register the direction of shift is also of value.

The shift of the tube may be either horizontal or vertical. There is, of course, a decided limit to the amount the tube may be shifted across the Bucky grids without increasing the amount of radiation intercepted and the danger of grid lines. Most grids will permit about a 3 inch shift across the table. The vertical shift can be used to any desired degree without influencing Bucky factors and so is generally preferred.

Another type of stereoscopic apparatus, the Stanford, is characterized by illuminators placed side by side close together. For visualization double mirrors are made use of. Thus reversal of the films is not called for. To arrange the films one superimposes them tube side up and again places the film whose image is nearest the right in the right hand illuminator, this time with the tube side facing the mirrors.



CONSULTATION TYPE STANFORD STEREOSCOPE

Recent Proposals in Stereoscopy:

1. Image shift of 3/8 inch.

A characteristic of roentgenological stereoscopy is that the image shift on the two films will vary not only with the tube shift, but with the distance the object to be visualized, is from the film. Parts near the film will show little shift and remote parts much. In routine work this does not appear to have troubled radiologists to any notable extent, but it has been stated that there are often viewing difficulties when the image shift exceeds 3/8 inch or about 1 cm. (0.95). The relationship of image shift in the two stereo films, to the object film distance and anode tube distance is given as follows: If A = Film Anode distance, B = Film Object distance, X the shift desired to obtain a 3/8 inch image shift; then -

$$3/8 : B :: X : (A-B)$$

Thus if we have, for instance:

B = 2 inch (object film distance)..

A = 36 inch (anode film distance).

Then - $3/8 : 2 :: X : 34$

$$2X = 3/8 \cdot \frac{34}{1} \quad ; \qquad X = 6\ 3/8 \text{ inches for the tube shift.}$$

The two inch object film distance approximates conditions in stereoscopy of a thin part, employing a plate tunnel and the figures thus indicate that for this type of work the usual shift of $3\frac{1}{2}$ inches (for 36 inch anode film distance) needs an increase of almost 3 inches.

Applying the same formula to a 6 inch object film distance, we obtain 1-7/8 inches as the proper shift. This would often apply to Bucky work such as studies of the lumbar spine and pelvic girdle. It is less than the usual shift.

In tests at the Medical Center, employing this new method, stereos of the wrist gave the sensation of increased depth but stereos of the lumbar spine and pelvic girdle gave the sensation of decreased depth. General utility appears doubtful but the procedure is interesting and it appears worth while to keep in mind in the event of special circumstances or difficulties and for further study.

2. Single Film Stereoscopy by Polarization.

(a) A method recently publicized calls for taking two films with the 3/8 inch image shift, printing them on Wash Off Relief films and finally transferring these images to polarizable material. Viewing is accomplished by use of polarized glasses. By means of a depth grid and polarized rulers, calculation of the depth of foreign bodies is possible.

Excellent views have been made by this method and it appears well worth while for special exhibit or museum films. It is scarcely applicable to routine use in a busy laboratory, especially in war time.

(b) By lenticulated film.

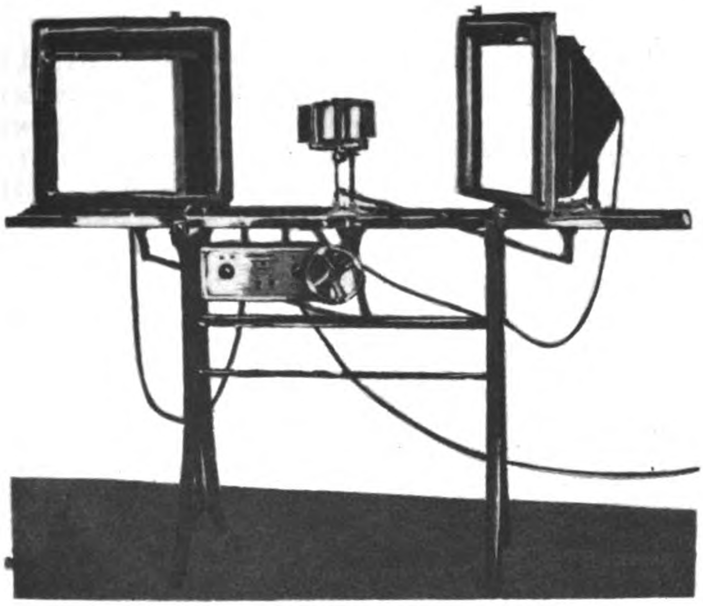
A single film, embossed with accurate microscopic ridges possessing lens effects, is used in a fluorographic assembly. This method is still experimental, although interesting results have been obtained.

3. Stereo-fluoroscopy:

Apparatus is now available for this purpose and apparently is mechanically adequate. Operation is by production of alternate images from two tubes on a single screen of minimum-lag type. A revolving mechanism insures that each eye sees only the appropriate images. There are 120 images per second.

This intriguing subject has been studied repeatedly and various ingenious devices contrived to little avail. Part of the trouble, at least, in the past has been mechanical but there is also a fundamental physiological difficulty which still applies, namely, limitations in retinal sensitivity. At the low illumination level characteristic of fluoroscopic screens, visual acuity and intensity discrimination are notably impaired. The result is that in any but thinner parts of the body fluoroscopic depth perception of detail is dulled to the point of inutility for most purposes.

Aid in fracture reduction, foreign body localization and bronchoscopy is stressed as a benefit to be conferred by such apparatus and there is no doubt that at times such will be the case. On the other hand let it be remembered that reduction of fractures under the fluoroscope is frankly dangerous and to be kept at a minimum, that fluoroscopic diagnosis in general has serious limitations and that there has possibly been more preoccupation with the matter of foreign bodies than truly warranted. All this and the matter of expense and space should be balanced against the benefits and in view of the particular needs of the hospital concerned, before acquiring such units.



WHEATSTONE STEREOSCOPE

FLUOROGRAPHY

This, as the name implies, refers to photography of the fluoroscopic image. Since fluoroscopic light obeys the usual optical laws, it can be focused by a camera lens and produce photographic pictures. Attempts at fluorography were made from the earliest days of roentgenology, but it is only in recent years that the method has really become practical. Improvements in screens, films and lenses have made this possible.

There are numerous uses to which fluorography can be put but the chief one at present is for mass chest surveys employing 35 mm. film. This is because the method makes possible such surveys with a minimum of expense and labor, and a maximum of speed and efficiency. In addition, the room needed for filing space is enormously reduced. Critical war materials are also conserved. Another method in common use calls for 4 x 5 inch views. These are also excellent but entail more expense, labor and time.

The Bureau of Medicine and Surgery has installed a number of units for 35 mm. chest work and in consequence X-ray technicians in the Navy need to become familiar with their use.

General Account.

X-ray Units:

Most installations employ the regular 200 M.A. X-ray unit with four valve rectification. These are similar to the usual radiographic units already described. Some of the later ones are of the less familiar condenser type. Thus, in the following, a detailed account of the operation of complete fluorographic assemblies employing a condenser X-ray unit will be given, followed by notes on the employment of a conventional X-ray machine.

The condenser discharge unit used is of half wave rectified type employing two valve tubes. Its capacity is adjustable to 1/4 and 1/2 microfarad (MFD). The unit may also be used as a conventional 30 M.A., 85 K.V.P. half wave rectified, pulsating generator. Its parts are: High tension transformer; four 1/2 MFD condensers, control unit to be placed on any convenient support; timer and push button; X-ray tube.

The tube for this unit is of shock-proof double focus type. Its anode is cooled by a forced draft blown over fins in the tube housing. The small 2.3 mm. focus is for the 30 M.A. pulsating current. The large 4.2 focal spot is for the condenser discharge current.

The X-ray condenser unit calls for the usual 110 volt, 60 cycle A.C. current. It can be adjusted for a voltage range of from 100 to 130 volts. The capacity of the line is not of primary importance, but operation of the unit will be more efficient if the line capacity is good. This is because the condensers will naturally charge faster with larger in-coming current. Good current supply means a charging time of about 5 - 7 seconds. Poor current supply means a charging time of 12 - 15 seconds. This difference is not negligible in mass survey work.

The grid is not used with the condenser unit due to insufficient capacity.

To obtain a good current supply it is well to connect the unit directly to the switch box or make use of a three pole connection instead of the ordinary two pole connector. At all events, make sure that the connections are good and the line not overloaded. A good ground connection must be made.

Photofluorographic assembly:

This is composed of a tube stand and camera-screen combination, connected by an overhead support and a cable system, by means of which adjustment of the height of both tube stand and camera unit is accomplished by a single handwheel. The tube carriage is supported on a single column. The camera-screen unit, mounted in a truncated pyramidal box which holds the camera in the small end and the fluoroscopic screen in the larger, is supported between double columns.

The camera is a 35 mm. Leica with f-1.5 lens coated for additional speed, and equipped to handle 36 exposure rolls. The fluoroscopic screen is of special type for photofluorography- Patterson Improved Type B. Special film is used and is obtainable from Eastman and Agfa.

Rooms:

The room for operation of the unit should be of ample size, at least 12 x 24 ft., and well ventilated. The doors should be so placed as to provide for ready in and out flow of the subjects in a steady stream. Lead or equivalent X-ray protection will be necessary unless the room is particularly remote from other office space and the dark room. (See section on X-ray protection).

The dark room should be at least 6 x 8 ft. in size and provided with hot and cold running water, and protected from X-ray and light leaks. Ventilation should not be forgotten. Illumination by a Wratten #2 safe light is permissible for developing Eastman film; Agfa film should be developed in complete darkness.

It should not be forgotten that space must be provided for other phases of the work. There is need for the following:

1. A small office or alcove for the admission desk and such files as may be kept there.

2. Office and reading room for the roentgenologist.

3. Dressing room space with facilities for both sexes.

4. Waiting room.

Technicians:

Two expert operators are needed along with several assistants (number depending on volume of work) for general utility, filing work, etc.

Identification:

Lead letters and numbers are supplied with the unit. A special holder is fastened to the screen end of the pyramidal box. Place, date and serial number should be included. To insure proper identification, the office man who logs the subjects should write the proper serial number on the subjects shoulders using an indelible pencil or other convenient means.

Operation details:

The control room should have posted in it charts of tube capacity, thickness of part K.V.P. and any other essential data.

Care and precision are essential. Usual electrical and X-ray precautions are to be followed. Avoid rough handling. Apparatus must be properly connected and handled. Operation of the condenser unit involves the following points:

1. Provide a good connection both to the main line and ground.

2. Use push button and <u>not</u> the timer; make all necessary adjustments for using the apparatus on the condenser discharge setting of proper capacity. The filament ammeter is not used on the condenser side and should be kept at lowest setting.

3. In operation, the K.V.P. is set, the patient positioned and then the condensers are charged by depressing the push button until the M.A. needle has reached the space between "O" and a special red line. The exposure is made by releasing the push button.

   Charging usually requires from 4 to 8 seconds and this period can be well utilized for final instructions to the patient relative to breathing and posture.

<u>Note:</u> To discharge the condensers without making an exposure, simply turn off the main switch while continuing to hold down the push button.

Before making any exposure be sure that:

(a) X-ray and camera settings are correct. (See capacity chart).
(b) Apparatus is properly adjusted.
(c) The subject is correctly positioned. (See under "Posture").
(d) Film not in use is safely disposed of.

Tube capacity must not be exceeded. Consistent or unduly frequent exposure to X-ray on the part of anyone must be avoided. Persons regularly on duty with the unit should keep out of all direct radiation. The X-ray tube is centered on the middle of the screen, or slightly above, at an anode screen distance of 38 inches. A lead screen (preferably built in) should be used to protect the man who operates the camera as he is in direct line with the X-ray beam. All other men should stand well behind the tube.

During the charging period there is often slight emission of X-rays. Attendants should keep out of their range during this period.

The camera is preset for proper focus. The f-1.5 aperture must be used. See that this setting is not accidently changed while attaching the camera to the unit. The lens elements, as noted, are coated to give extra speed. The coating is easily damaged and all lens elements so treated must never be touched with the fingers. In practice there should be no trouble about this as the outer surface of the front lens element is uncoated. Nevertheless this surface should likewise never be touched with the fingers. Keep the lens cap in place when camera is not in use. Always store the camera in a safe place and handle gently.

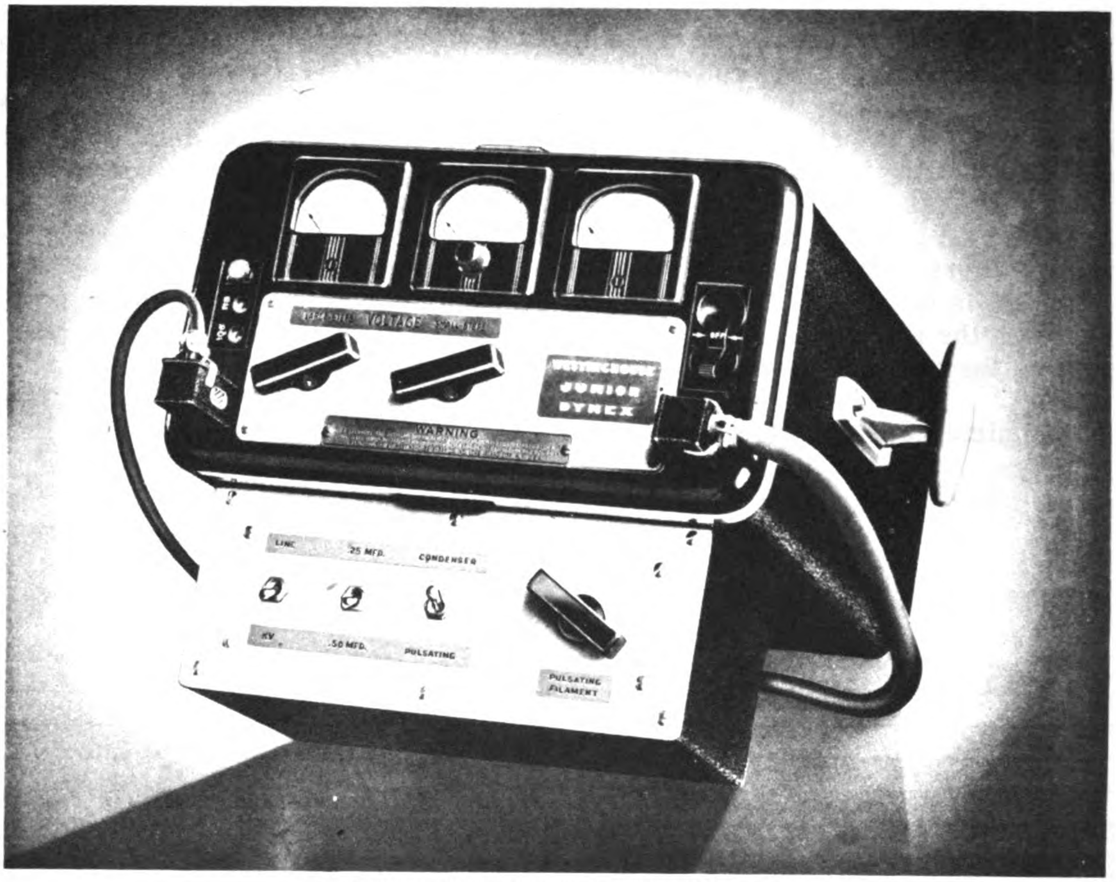
Technical considerations:

X-RAY EXPOSURE CHART
Condenser Unit

	For 35 mm. Fluorography 1/2 MFD	For 14 x 17 film 1/4 MFD
Thickness in Cm.	KVP	KVP
16	53	39
17	54	41
18	56	43
19	58	45
20	60	47
21	63	49
22	65	51
23	68	53
24	70	55
25	73	57
26	76	59
27	79	61
28	82	63
29	85	65
30	88	67

Note: 1/2 MFD side gives M.A.S. equal to 1/2 KV used: 1/4 MFD side gives M.A.S. equal to 1/4 KV used. Example: At 88 KVP 1/2 MFD gives 44 M.A.S. At the same KVP of 88 on 1/4 MFD we would get 22 M.A.S.

Subjects who have very heavy muscular development require 3 to 5 K.V.P. more than the chart indicates. The scale may need to be shifted up and/or down relative to thickness of part, owing to differences in film speed or degree of density desired. A trial run will serve to indicate optimal exposure technique.



CONDENSER DISCHARGE CONTROL

Mobile Fluorographic Unit:

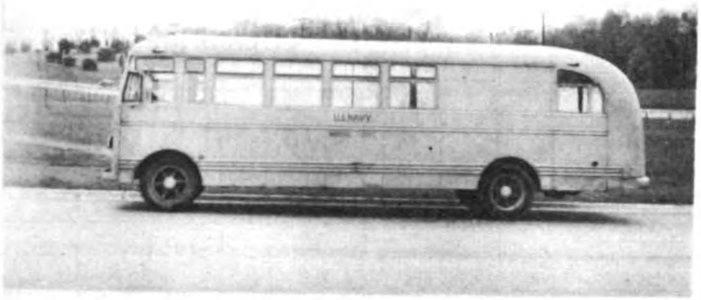
The mobility of Photofluorographic equipment makes it ideally suited for chest surveys of large military or civilian populations located at points isolated from fixed activities. To this end many organizations have mounted this type of apparatus in various types of motor vehicles. The Navy has placed condensor-discharge units permanently in two buses. This unit serves this type of duty well because of its ability to overcome unstable power lines in the field, and it will also stand the abuse of road vibration.

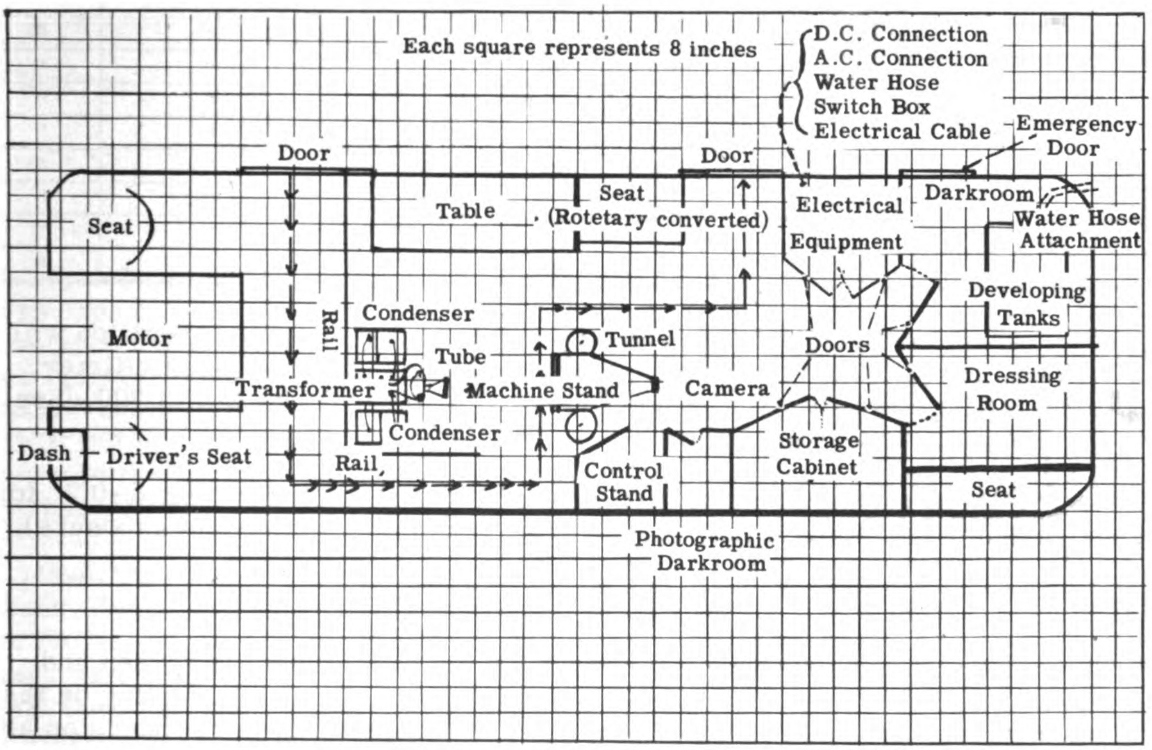
The general plan of the interior of these units, embodies all features of the fixed installation in a very compact space. The units are entirely self-contained, as is noted from the diagram. Supplies, adequate for several months operation, and small equipment are secured in well-designed drawers and closets. The tube is removed from its stand, and,without disconnecting the cable, placed in a cradle in a nearby cabinet. This protects the delicate tube from vibration while the unit is enroute. Adequate passageways are left for efficient operation.

All clerks, positioners, operators, and film--processors, work at stations within the unit. The personnel to be examined enter the front door of the bus, stripped to the waist if male, robed if female. They pass through the various stations from clerk to operator, just as in the fixed type of unit, leaving through the back door.

The films are processed in a completely equipped darkroom in the rear of the bus. The Medical Officer in charge, who travels with the unit, interprets and reports the films as described on preceding pages. All individuals requiring 35 mm. retakes and 14 x 17 studies are called back before leaving the activity. Two technicians permanently attached to the unit perform all technical duties, and double as drivers enroute. The other help is recruited from the station at which the survey is being made.

Electric cable and water hose, carried on a reel in the unit, are attached to sources of supply within nearby buildings. The unit can be parked close enough to, or within such buildings that inclement weather is no hindrance to operation.





Floor Plan of Mobile X-ray Unit

Use of conventional X-ray Unit:

As previously noted, the 200 M.A. full wave rectified type is preferred. Naturally larger units may be used and may prove an advantage at times. Tubes of high capacity are essential such as a stationary anode tube of "E" type specially equipped with cooling devices such as a blower; a rotating anode tube is excellent and is usually preferred by most workers. The line current for these units must be 220 volts, 60 cycles A.C. The supply cables should be of ample capacity, likewise the pole transformer. Other heavy equipment, especially elevators, should not receive their power from this line.

The use of grids becomes readily possible with the conventional unit. This gives some increase in contrast and many believe that more latitude results. It is certain that with thick-chested individuals the grid is a decided help. Resolution is increased and its routine use is recommended.

Exposure charts, for use both with and without the grid, are supplied below:

No Grid				With Grid			
MA	Time	MAS	CM	KVP	MA	Time	MAS
200	1/10 second	20	15	58	200	1/4 second	50
"	"	"	16	60	"	"	"
"	"	"	17	62	"	"	"
"	"	"	18	64	"	"	"
"	"	"	19	66	"	"	"
"	"	"	20	68	"	"	"
"	"	"	21	70	"	"	"
"	"	"	22	73	"	"	"
"	"	"	23	75	"	"	"
"	"	"	24	78	"	"	"
"	"	"	25	80	"	"	"
"	"	"	26	82	"	"	"
"	"	"	27	85	"	"	"
"	"	"	28	87	"	"	"
"	"	"	29	90	"	"	"

If and when the automatic exposure meters become available, operation will be on the basis of variable MAS, the time being adjusted by the automatic timer. The kilovoltage is usually fixed at a high level (80 to 100) and the MA at 200. (See automatic exposure meter, appendix).

Fixed voltage without an automatic timer: 90 K.V.P.-200 M.A. - Grid -0.2" for thin chest, 0.3" for medium and 0.4" for heavy might answer.(Make test exposure).

Posture:

The subject stands about eight inches (mark on deck) from the screen and leans forward with the chest in contact, neck well extended and chin resting on the top. The shoulders are rolled well forward and the subject places his hands on his hips. This is the routine position for general work.

Adjustment for height is usually accomplished by a handwheel which elevates or depresses the camera and X-ray tube simultaneously. In some installations the camera is fixed in a lead lined booth and adjustment of height is by means of a "lift" or blocks on which the patient stands. Grouping of men by height will naturally speed up work. Centering should be near the mid-dorsal region; the 6th or 7th dorsal is usually considered optimal. Beware of trying for speed records. About 120 per hour makes a good number. Such is apt to cause poor positioning, movement of the subject during exposure and abuse of the X-ray tube.

Phase of Respiration: End of ordinary inspiration unless specially directed.

Filter: Inherent filtration of tube is sufficient.

Another view may be called for in which the clavicles are to be raised. This is readily accomplished by having the subject rest both forearms on his head during the exposure. Others favor the A.P. view as a valuable additional view, the idea being that the visualization of any lesions located posteriorly will be favored. Stereoscopic views can be made; also special views of either apex by slightly rotating the subject or having him stoop forward. However, studies so far have not indicated very marked benefits from multiple views and it appears that at least when mass surveys are carried out that the extra time, effort and material involved by such procedure may not be justified. In the case of the smaller groups or when special situations exist, the use of extra views may well be desirable. Future studies will probably throw more light on this matter.

Photography (35 mm. Fluorography):

1. Cameras.

(a) 36-Exposure camera.

1. Loading the 36-Exposure Cassettes into the Camera:

Remove the cover plate from the camera bottom by turning the swivel lock to "open". Remove both spools from camera. The film is supplied in 36-exposure rolls contained in light-tight loading cassettes. In addition, if it is desired to use bulk film, the daylight loading cassette supplied with the camera may be employed. The unexposed film from the loading cassette or sending spool, is pulled out until the full film width appears. The tapered end of the film thus exposed is inserted in the core of the receiving spool with the emulsion side (i.e., dull side) away from the core of the spool.

Insert the receiving spool and sending spool into the camera as follows: With the back of the camera towards and lens away from you, open or bottom side up, place the sending spool in the right side and the receiving spool in the left side of camera, allowing the film to lodge in the track against the camera back, and being certain that the emulsion side faces the lens. Replace the cover plate and fasten the swivel lock to "close".

The small lever near the winding knob should be positioned to A (advance) and

the winding knob advanced one full turn. In order to dispose of the useless tapered film the winding has to be repeated once more. This is accomplished by first pressing the shutter release button which is located alongside of the numbered dial and turning the winding knob once. When film cartridges are being used, the first winding must be done carefully since the film is liable to be difficult to withdraw at first. Turn the numbered dial (exposure counting device) which is located beneath the winding knob, by means of the two lugs which project up on the scale surface. This should be turned to the left, against the direction of the arrow on the winding knob, to zero position.

2. Aperture, Focus and Shutter:

The aperture of the lens is always set at f:1.5.

The range focus adjustment should be such that the figure 3.5 is directly in line with the Figure 9. This is the only setting which will allow the placement of the camera in the adapting collar on the photofluorographic hood.

On this camera there is a Master Shutter Control which is situated on the top of the camera. It is a small quarter circle of metal fastened to the large knob near the shutter release button. When it is in the "down" position the shutter remains open at all times. It is necessary to place it in the "up" position only when it is desired to have the shutter closed. This would be for reloading, removal of the camera, etc.

3. Winding of the Film in the Camera:

The advance of the film from picture to picture is obtained simply by turning the winding knob in a clockwise direction until it stops. (The evidence that the film is winding properly is the rotation of the back-winding knob against the direction of the arrow. This must be given particular attention when starting to use a new roll of film). It is necessary to press the small release button beside the winding knob in order to turn the film to the next position.

4. Rewinding of Film:

To rewind the film at the completion of 36 exposures, move the Master Shutter control to the "up" position and press the release. This will close the shutter for rewinding. Put the rewind lever in the R, or rewind position. Lift and turn the knob on the opposite end of the camera from the 36-exposure sending spool. (This is the rewind knob and is used to rewind the film into the magazine which facilitates movement of the film from the camera in daylight).

When the film is almost completely rewound in the magazine, the rewind knob will feel slightly taut. At this point the film is disengaging the winding spool and should be turned until the tightness is relieved.

<u>Do not turn the film beyond the point at which this tautness is relieved.</u>

The magazine is removed from the camera with a small section of the film

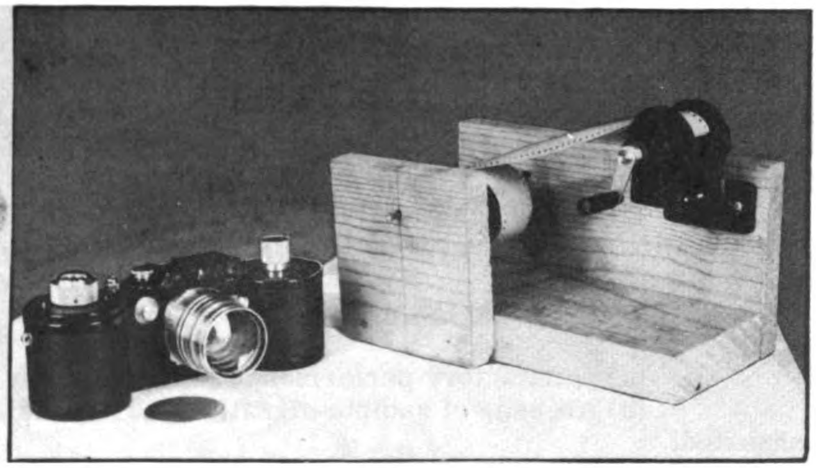
free. The free end will facilitate development. The film can be wound on to the developing hanger from the magazine without unnecessary handling.

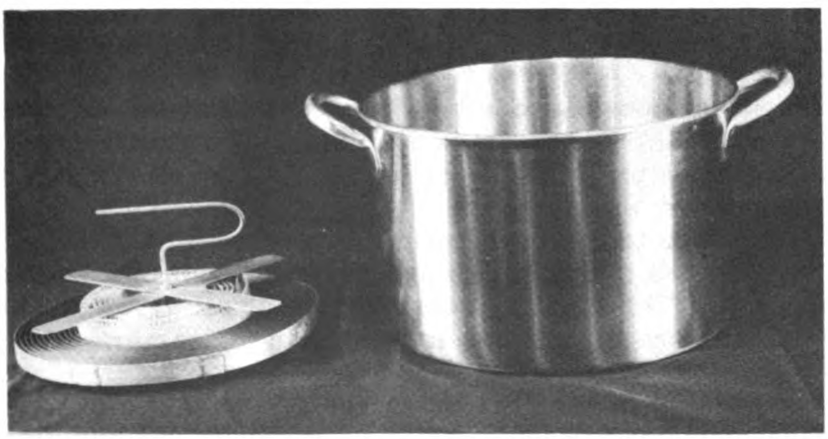
Care should be taken in withdrawing the film from the magazine because if it is done too rapidly, static electricity will be generated which will leave marks on the film.

(b) 250-Exposure camera.

A few of these camera are in operation. They are essentially the same as the others except for holding a larger film magazine and in some instances a regular camera shutter. The operation involves no special difficulties and needs no detailed description, except that film for these cameras is usually cut from a 100 foot roll, the ends need to be shaped for the spool and tracking device. This is readily accomplished by use of a special guide called a "Template".

The film is wound on the spiral reel for processing. A tank of sufficient size is provided to contain the reel.





(c) Automatic camera: **This uses unperforated film and produces a larger image (Pyramidal Box shortened; lens the same).**

(c) Automatic camera.

1. Directions for Loading.

Illustration shows the automatic camera loaded and with door opened. Directions for loading are as follows:

(a) Remove guard J, from take-up roller, G.

(b) Push the lever H, away from the supply spindle A and place the roll of film (maximum length 50 feet) on the spindle. The film is rolled emulsion side in and must be placed so that the roll turns counterclockwise as film is fed off.

(c) Release lever H, to bear against film.

(d) Thread the film over guide B, then in front of pressure gate I and over guide C. The emulsion must face the lens L and the pressure gate seat snugly against the film. This keeps the film in focus.

(e) Next thread the film between the guide assembly D, E and F.

(f) Insert end of film in the slot of winding spool and give the spool several turns counterclockwise to anchor film.

(g) Close lid K and lock securely.

(h) Mount camera on the fluorographic assembly as illustrated. The short cable connects the camera to the camera control; the long cable connects the X-ray and camera controls.

(i) The toggle switch on camera control is placed in the "on" position. The camera will now advance films either by pushing a button on the camera control or automatically at the termination of each X-ray exposure. An audible signal is made while the film is being advanced.

(j) Advance a few frames of film by use of the camera push button to test operation and prevent use of film injured or fogged.

2. Operation Pointers.

(a) Satisfactory performance is indicated by the audible signal.

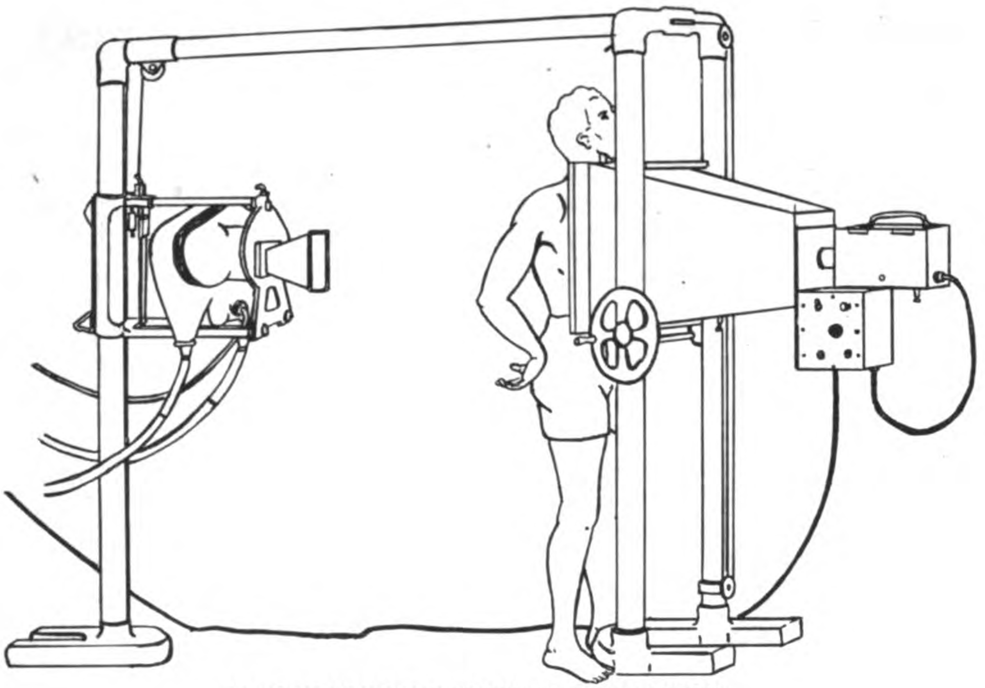
(b) Absence of audible signal ordinarily indicates that film supply is exhausted.

(c) Continuation of the signal ordinarily signifies that the film is failing to advance due to jamming of the film or failure of some mechanism. In either case inspection is called for.

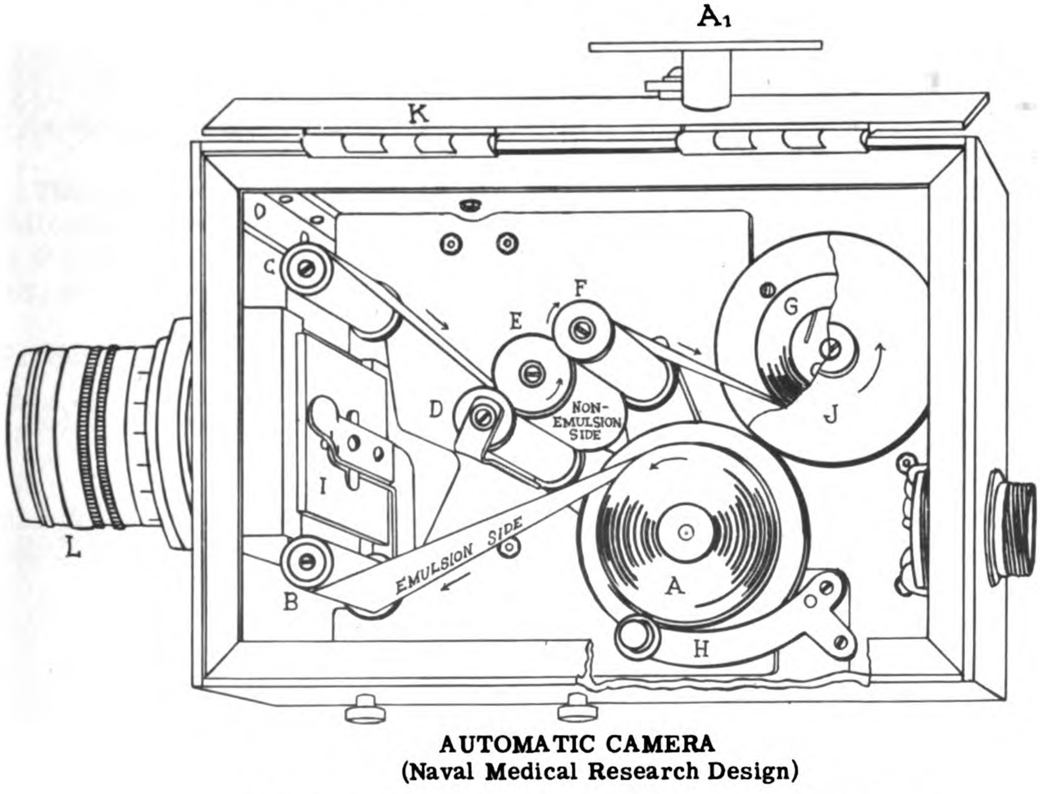
(d) Whenever possible, use the commercial film in 50-foot rolls. When necessary to wind from a larger roll it is absolutely essential that the film edges be perfectly even. Otherwise binding will occur and the camera will fail to function properly. The film should also be wound as snugly as possible.

(e) To advance the last few frames of film without opening the camera, it is necessary to close the micro switch opened as a result of exhaustion of film supply of sending spool. This is made possible by a small arrow-shaped switch on the right side of the camera box. If this is held down the camera will continue to operate.

(f) Whenever film has been left in the camera even for a short period of time, always advance one frame of film before starting work. The original frame will often be accidentally exposed.

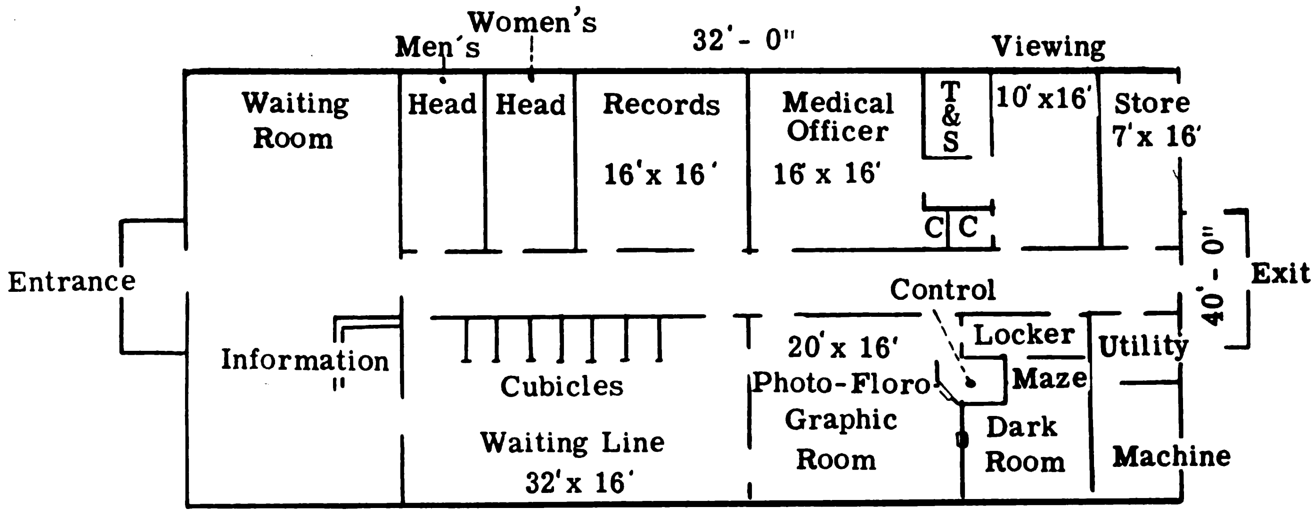


FLUOROGRAPHIC UNIT IN OPERATION



AUTOMATIC CAMERA
(Naval Medical Research Design)

A, Film supply; B,C, Film guide; I, Film pressure gate; D,E,F, Film guides; G, Take-up roller; H, Film supply indicator, controlling safety switch; J, Guide for take-up roller; A' Film supply guard.



Floor Plan Scale 1'/16" = 1' 0"

Photo-Fluorographic Unit
Standard Layout
Schematic Bumed 4-14-44

(g) If unperforated film is not available, use of perforated film is permissible.

(h) Use of the small camera naturally will involve replacing the original camera end of the pyramidal box.

(i) The lead glass screen should not be entirely neglected, it may need cleaning and, of course, if cracked should be replaced. It should not be forgotten that the lead glass is needed to prevent damage to the camera lens as well as possible fogging of films.

(j) The Eastman Recordak Camera can be adopted to this modified pyramidal box without undue difficulty.

3. Unloading.

Unloading will differ depending on whether or not the full roll is to be removed.

(a) Removal of partial roll: Cut the film near guide B and wind on the receiving spool. This can be turned by hand after raising it slightly to disengage from turning mechanism. The spool can now be removed and the film developed.

(b) The film left on the supply spool may now be threaded to another receiving spool as already described.

(c) It is worth noting here that after 85 exposures are made, the length of film used is such that the usual developing hangers may conveniently be used. For greater lengths use the spiral processing device.

2. Processing equipment.

This may be simple or elaborate as circumstances may call for and includes the following: Special hangers or spiral reels for film; appropriate developing tanks for 35 mm. (and 14 x 17 film if possible); drying equipment; viscose sponges; scales; safelight - Wratten #2; thermometer; graduates, etc.

3. Processing solutions.

(a) Developers:

1. After extensive experiments the following formula has been found optimal for this type work and is accordingly recommended by the Naval Medical School.

*Water 125° F	500 cc.
Elon	11 Gm.
Sod. Sulphite (anhyd.)	56 Gm.
**Alkanol B (Sat. Sol.)	8 cc.
Water to make	1000 cc.

*Distilled water best but not essential.
**Solubility of Alkanol B is 6 Gm. per 100 cc. water. It can be obtained from DuPont DeNemours, Wilmington, Del.

Developing time: 35 minutes at 70° F. Higher temperature unsatisfactory as emulsion may be damaged due to length of developing time. At low temperatures time may be extended to as much as 2 hours.

Films must be agitated constantly for first 2 minutes and every half minute thereafter.

Above formula gives fine grain development for orthochromatic and panchromatic film as follows: Ortho. 11 mins., Panchro. 13 mins. at 68° F.

2. Commercial X-ray developers. Of these DuPont and Eastman have been found to give excellent results. They should be used between temperatures of 65° and 68° F.

Developing times for the standard solution (not the extra fast type) are: Eastman film 10 minutes and Agfa film $7\frac{1}{2}$ minutes, at 65° F.

The formula already given in this manual for X-ray film will also answer. Time should be the same as above (10 minutes for Eastman and $7\frac{1}{2}$ for Agfa).

(b) Short-stop:

Glacial Acetic Acid (or Citric Acid).. 1 oz.
Water..32 oz.
(Make fresh daily).

(c) Fixer: Any good standard X-ray or Photo fixing solution is suitable.

Processing Details:

(a) Attach film to developing hanger, or wind on spiral, emulsion side out. Don't touch emulsion with the fingers. Winding on spirals must be snug to prevent any contact of the emulsion side of the film with an adjoining spiral.

(b) Immerse in developer. There must be sufficient solution to completely cover film and permit up and down motion without the film being uncovered; agitate throughout development, frequently at first to dislodge air bubbles and at $\frac{1}{2}$ minute intervals thereafter.

(c) Immerse film in "short stop", temperature 65° F. for 1 minute; agitate.

(d) Place in fixer and agitate. Time: Not less than 10 minutes, not over 20 minutes. Temperature 65° F.

(e) Wash 30 minutes in running water at about 65° F., or 6 complete changes.

(f) Remove excess water with viscose sponge and hang film up to dry or wind on drying drum, emulsion side out. Where there is sufficient volume of work, it is a good idea to mount a drying drum above the wash tank, thus the film can be passed through the sponges and onto the drum directly from the wash tank.

4. Viewing.

A special Leitz viewer is used. Its magnification is about 3.8 times. It has a focusing lens and can be used for film strips or slides in either vertical or horizontal position. Light intensity is variable. Projection devices can also be used. In this event a very fine grain screen is desirable. At ordinary viewing distances moderate enlargement to a size no greater than 6 x 8 inches will probably be found best under present conditions.

5. Disposition of films and reports.

After viewing, each film is detached and enclosed in a 2-1/2 x 4-1/4 inch envelope, showing date and place of examination, the full name of the examinee, date and place of birth, the service number, the film number, the report of interpretation, and the name of the roentgenologist. These envelopes will be initialed by the examiner and, in the case of new personnel, forwarded to the Bureau of Medicine and Surgery for file. In the case of other personnel, disposition of films and report will be in accordance with local instructions. A signed entry is made on the history sheet of the health record showing this data. A rubber stamp made as follows is convenient:

Medical Department, U. S. Navy.
Fluorographic Examination of the Chest.

Station________________________

Date________________________ File Number____________________

Name________________________

Service Number____________________

Date and Place of Birth____

Report____

____

____
(MC), U.S. Navy.

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6. Miscellaneous Notes:

(a) Teamwork:

It is obvious that a well organized team will accomplish a great saving of time and produce superior results. The converse is also true. Poor team work will also infinitely increase the amount of error.

An organization for large scale work might well be as follows:

1. Clerical Man: Logs the name of each person in the work book and assigns a file number; also checks the names against any list which may, and should be, provided.

2. Assistant for Measuring: Takes greatest A.P. thickness of chest and preferably marks this figure on the patient's shoulder. This is a most important detail as carelessness will cause poor results. A common error is to obtain a low reading by applying calipers to the upper lateral chest, thus obtaining figures more nearly approximating those for the shoulder. The calipers can be graduated to read directly in K.V.P.

Naturally if an automatic timer is used, the services of this assistant will be dispensed with.

3. General Assistant: Puts proper number in place on screen and acts as M.A.A. to keep men in line and maintain steady progress. Needless to say errors in file number will occasion enormous confusion and delay.

4. Assistant for positioning: Attends to posturing the subject and adjusts the apparatus to proper height.

5. Camera Operator: Takes care of all photographic details.

6. X-ray Technician: Takes care of all the details pertaining to the X-ray apparatus.

(b) Technical Quality:

Good technical quality is an absolute essential, even more so than with conventional films. If the apices are not well visualized or various other technical faults appear, recheck views are in order. Films that are too light will leave one in doubt as to the apices and infraclavicular regions. Films that are dark will have soft detail "burned" through. These extremes must be avoided.

(c) Diagnostic status:

Minature films do not have the diagnostic precision of 14 x 17 celluloid films and are not intended for differential diagnosis. The small films are intended only for the purpose of "sieving out" the abnormal and suspicious cases for further study. The percentage of cases thus discovered varies considerably depending on the type of personnel examined. In Naval practice, which involves people who have already been subjected to a fairly rigid physical examination, it is usual for one or two percent of 14 x 17 films to be called for. When the general population is surveyed, this percentage may rise to four or five percent, or even more. It is best to be quite liberal in calling for 14 x 17 rechecks, at least until considerable experience with the small film has been obtained.

The cases in which the 14 x 17 inch films verify abnormalities as being present and of clinical significance are ordinarily transferred to a Naval Hospital for

study and final disposition.

(d) Prospective Developments:

The technique for 35 mm. film has now attained a fairly high level and procedures have been standardized to a considerable extent. This does not mean there is no room for improvement and that further investigations will not be made.

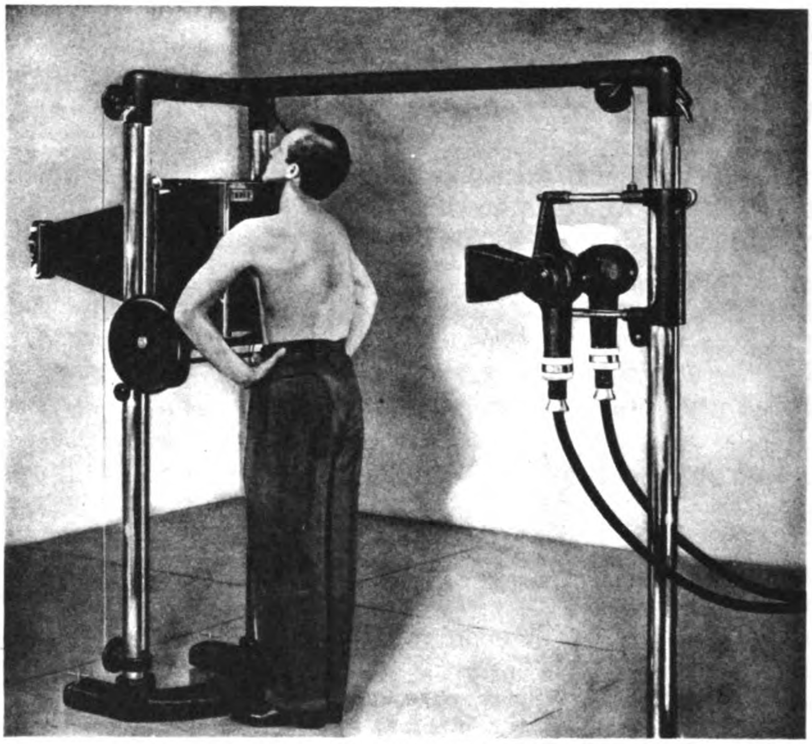
Improvements are looked for in optical equipment, screens and film. It is hoped that eventually electronic activation of the fluoroscopic screen may become practicable, thereby enormously increasing the amount of illumination and making possible use of fine grain film and slower lenses of greater resolving power.

Discussion of the optimal size for chest fluorographs still goes on. Our position still remains the same: That the minature fluorograph is the most economical and most practical for large mass surveys, such as we are largely concerned with in Naval practice. However, the 4 x 5 inch fluorograph is preferred by a number of workers and possesses the notable advantage of being readily interpreted by direct inspection as well as affording some increase in detail. The greatest drawback with this size is the present necessity for individual processing: moreover, expenses are greater, filing space requirements more and lenses slower.

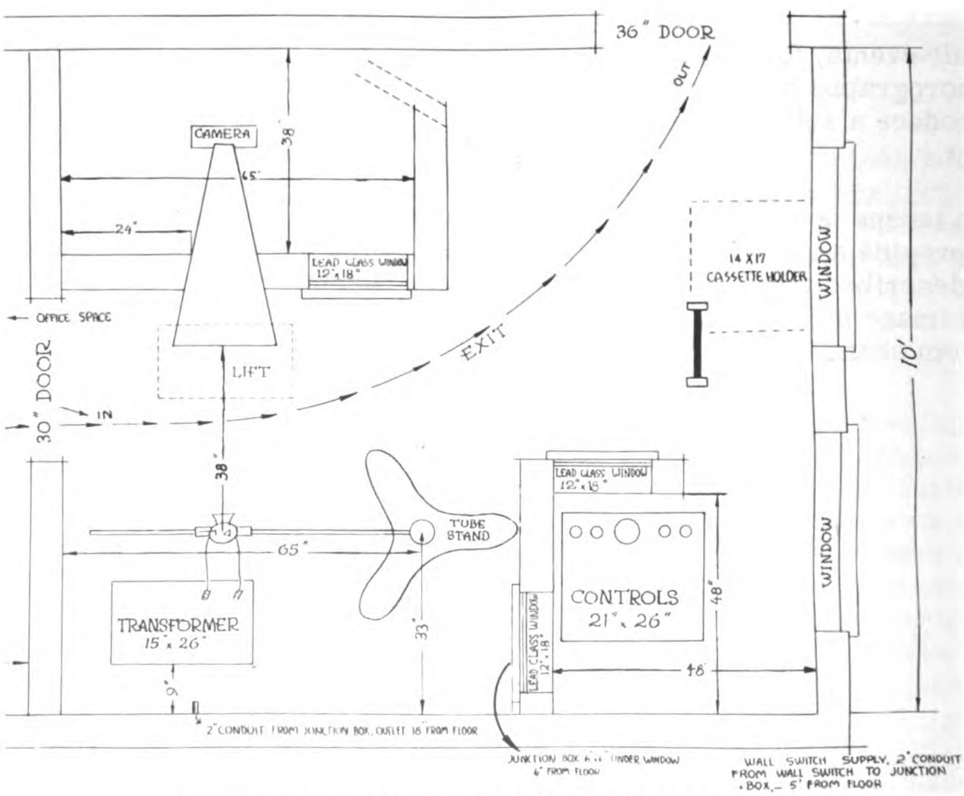
Seventy mm. (about 2-3/4 inches) roll film has recently been advocated in England to provide a film suitable for direct viewing. It is doubtful, however, if many radiologists will wish to deal with anything smaller than the 4 x 5 inch or possibly 3-1/4 x 4-1/4 inch sizes for interpretation by direct inspection.

At all events, for certain types of work and under certain circumstances, the larger fluorographs have their place and it is hoped that our Manufacturers will be able to produce a roll mechanism to speed up this type of work and make it more convenient.

The lenses now in use for 35 mm. film can also be adapted to 46 mm. film and thus provide a larger image and accordingly a slight increase in detail. However, as described previously, we have found it possible to obtain a decided increase in image size by utilizing the 35 mm. film to better advantage. Thus any benefit from changing to the 46 mm. size is considerably reduced.



PHOTOFLUOROGRAPH CONDENSER UNIT



FLOOR PLAN FOR PHOTOFLUOROGRAPHIC UNIT

SECTIONAL RADIOGRAPHY:

This type of radiography is also spoken of an Laminagraphy, Stratigraphy, Tomography and Planigraphy. The principle of this procedure is to secure improved detail in certain of the planes of the body, and blur out the other planes. This is accomplished by various reciprocal motions of the X-ray tube and film. These move in opposite directions about an axis adjustable as to height, with the result that the structures in the plane of the axis produce shadows which do not move on the radiographic film whereas the shadows of structures in other planes do move relative to the film and so are blurred out. The more common types employ linear motion and it is possible for an ingenious individual with access to a good machine shop to build a satisfactory apparatus of this type which can be used with his radiographic table. Manufacturers also supply linear types to be used with their regular X-ray tables. Probably the most satisfactory unit is the one designed especially for this work and which makes use of circular and spiral motions of variable diameter. This is the Kieffer Laminagraph.

The laminagraph is not a substitute for regular radiography but an additional mechanism for the purpose of better visualization of certain structures such as the upper cervical vertebrae, upper dorsal spine in lateral projection, sternum and sterno-clavicular joints, the larynx, certain parts of the skull, the lungs and parts obscured by heavy casts. The objections to sectional radiography pertain to hazy definition, the time and trouble occasioned, heavy exposures and the need of multiple views at varying depths. This last feature also involves considerable expense. Nevertheless, laminagraphs quite frequently yield important information and although they are not in routine general use, the larger institutions often find the apparatus well worth having.

To obtain good results with a minimum of labor and expenditure of films, it is necessary to adjust the apparatus for the proper depths. Hence a knowledge of depth relationships of the parts to be examined is essential. Aid from the radiologist should be sought and he will usually specify the depths but the technician will do well to study the matter himself so as to be of more aid to the radiologist.

Some sample techniques are tabulated to give an idea of main factors.

First, however, a few technical considerations need mention.

1. The distance of the plane to be radiographed from the table top is picked and the machine adjusted accordingly. This plane is called the "datum plane".

2. Thickness of the "slice" is to be determined. The wider the circle of the Kieffer apparatus or the greater the sweep or amplitude of the linear type, the thinner the "slice" will be. Thus technique may call for varying lengths of sweep, or, circular or spiral motion of certain amplitudes.

Spiral motion gives a greater latitude as to depth as it is slightly less critical as to the precise datum plane. The larger spiral starts with 8 inch diameter and diminishes in five turns to about 2 inch diameter.

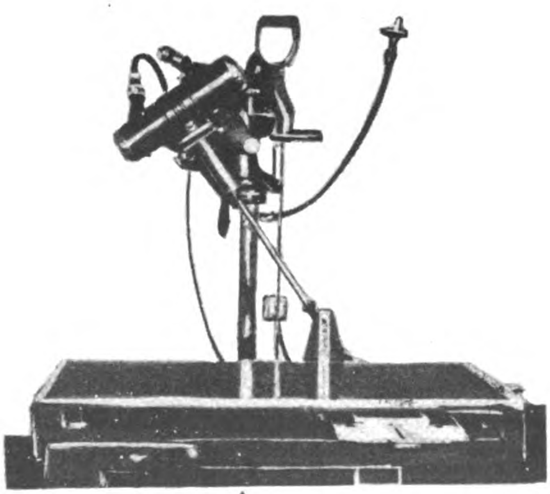
3. Exposure and motion factors are adjusted so that appropriate exposure continues throughout the required period of reciprocal tube-film motion. M.A.S. are constant for a given part. K.V.P. is varied with thickness of the part and is best recorded as the K.V.P. factor. This is a number to be added to twice the thickness of part in cms. Thus with a factor of 30 and thickness of 16 cms. we would get a K.V.P. of 30 plus(16 x 2)or 62.

4. Use of a grid is advisable and the wafer grid answers the purpose well.

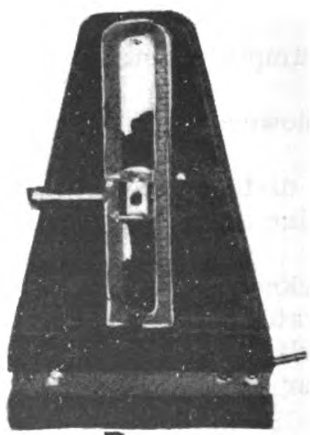
EMPLOYING DOUBLE INTENSIFYING SCREENS (Par Speed)

Part	K.V.P. Factor	MA	Time	MAS	Sec. Per Revolution.	Amplitude	Average Datum Plane	Anode-Film Distance
Skull, Sella Turcica Lateral	27	33	7	232	2-1/3	8" Spiral (3 turns)	7.5 - 8 cms.	36
Chest	30	33	1	33	1	4" Circular(1 turn)	varies	36
Sterno-clavicular	30	33	3	99	1	5-6" Spiral (3 turns)	2-2.5 cms. (Prone)	36
Patella	42	33	3	99	3	4" Circular(1 turn)	2-2.5 cms. (Prone)	36
Larynx	30-36	33	5	165	2-1/2	4" Circular	13-15 cms. (Supine)	36
Lateral Upper Dorsal Spine	32	33	2-1/2	82.5	2-1/2	4" Circular(1 turn)	14-18 cms.	36

Naturally if the planigraph type is used the length of the sweep is recorded under amplitude.

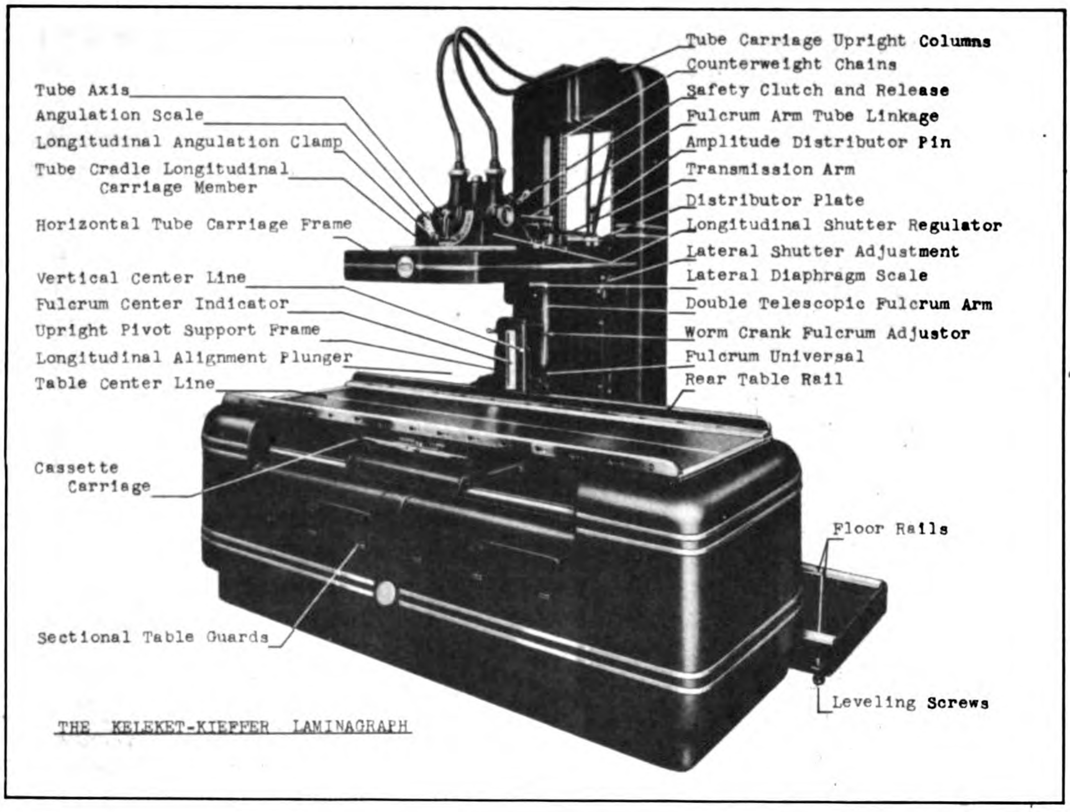


A



B

PLANIGRAPH



THE KELEKET-KIEFFER LAMINAGRAPH

KYMOGRAPH:

This is an apparatus for recording on the radiograph the motions of various organs, notably the heart. It consists of a lead plate in the form of a grid large enough to cover the 14 x 17 cassette, and provided with narrow transverse slits usually 0.4 mm. wide and 12.0 mm. apart, behind which grid is a cassette carrier. This carrier is designed to move downward at a uniform and adjustable speed. The X-ray exposure is made while the patient stands before the grid and the cassette is in motion. As a result, the horizontal motion of the heart borders projected through the slits, produces wave forms on the film which are often of diagnostic value.

In practice, the speed of the film motion is such that not more than two cardiac cycles will be recorded. More than two will result in compression of the waves vertically with loss in the detail of their form. Thus the speed is varied in accordance with the pulse rate of the patient. A time recorder is attached to the top of the kymograph and produces a narrow band of lines, the space between each one of which represents 1/5 second. The distance between the kymograph and anode is 30 inches.

Detailed operation is as follows:

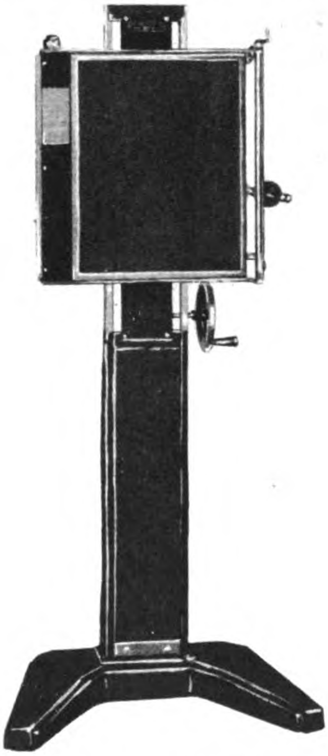
The pulse is taken with the patient standing. (Otherwise it may prove too slow). From the pulse rate, the exposure is calculated as follows:

Divide 60 by the pulse rate and multiply by 2. This gives the time in seconds

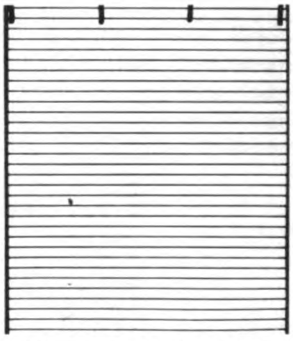
that should result in 2 cardiac cycles on the kymographic film.

For other exposure factors, the following will answer: 100 M.A.; 10-15 K.V.P. over the amount required for the conventional 6 ft. chest.

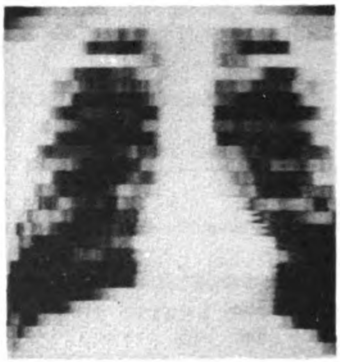
The kymograph has a time adjustment and is provided with contacts similar to those of the Bucky so that it can time the X-ray exposure directly or through the X-ray timer. In this latter case set both timers to same time.



KYMOGRAPH



Kymograph grid



Kymograph film

Another instrument, the Kymoscope is sometimes used as a supplement. Its purpose is to reproduce the movements of the heart by a reversal of the process by which the kymographic film was made. It is of interest to watch and is of occasional value in demonstrating certain conditions.

LOCALIZATION OF FOREIGN BODIES:

The problem of localizing foreign bodies is always with us and naturally is of special concern in war time. Various methods are in use, some simple and others elaborate. The procedure will have to vary not only with the particular requirements of the cases but with what may be practical under the circumstances. In general, simple methods will often suffice and may be all that can be carried out.

In the first place the presence of the foreign body will have to be determined. A glance under the fluoroscope may often answer but there will be more instances when such will be totally inadequate. Victims of bombing and other war time injuries

will have multiple wounds and moreover the foreign bodies will often have poor radiological density. The result is that preliminary radiography will be required in a majority of cases to determine the presence and approximate location of foreign bodies.

1. The simplest method of localization by radiography, and one that frequently will be all that is required, is simply that of taking two views or stereoscopic sets at right angles to each other.

2. When large numbers of cases have to be dealt with in a short space of time, often with limited facilities, the above method can be effectively applied to the fluoroscope and has proven very practical. The patient is fluoroscoped in the usual P.A. (or perhaps A.P.) position and the foreign body is accurately centered in the closely diaphragmed X-ray beam. The skin is then marked directly over the fragment. The same procedure is repeated with the patient in lateral position. The patient is then taken into the operating room with the two marks to serve as a guide to the surgeon. Since the marks are apt to be removed or concealed by antiseptics, they are usually "fixed" by superficial scratches.

3. Localization and removal under fluoroscopic control at the same time may often be practical and is often done. This may be quite easy. One simply centers the foreign body in the sharply diaphragmed X-ray beam, extends forceps down to it and removes it. Often enough, however, the process is not quite so easy as it would seem. Important blood vessels or nerves may be in the way, the object may be hard to seize, too firmly fixed or too jagged to come out readily; or it may tend to move away from the exploring forceps. In such case one may extend the forceps to the object and seize it, if possible, or if not to approximate it. One can tell if the tips of the forceps are near the level of the foreign body by watching the motions of their images as the fluoroscopic tube is moved. If both move together they are in the same plane. If one moves more than the other they are not. Whichever is closest to the X-ray tube will produce the greatest motion of its fluoroscopic image. Furthermore, when the forceps are close to the object it is apt to move as the forceps are prodded about. Finally, when the foreign body is seized or approximated as closely as possible, the lights are turned on and the surgeon carefully dissects down to the object and removes it.

4. Triangulation methods for calculating the depth of a foreign body are sometimes necessary as thickness and density of the parts of the body concerned or difficulty in moving the patient in various positions, may preclude use of more direct and simple methods. These triangulation methods depend upon the shift of the fluoroscopic or radiographic image of the foreign body as the X-ray tube is moved. The closer the object is to the tube the more its image will shift as the tube moves. In one method it is only necessary to measure (a) distance from anode to film or fluoroscopic screen, (b) distance of tube shift and (c) distance of image shift. Then if -

D = Anode film distance.
T = Distance of tube shift.
M = Distance image shift.
X = Distance F.B. from screen.
D-X = Distance anode to F.B.

We have the following proportion for calculation based on similar right triangles:

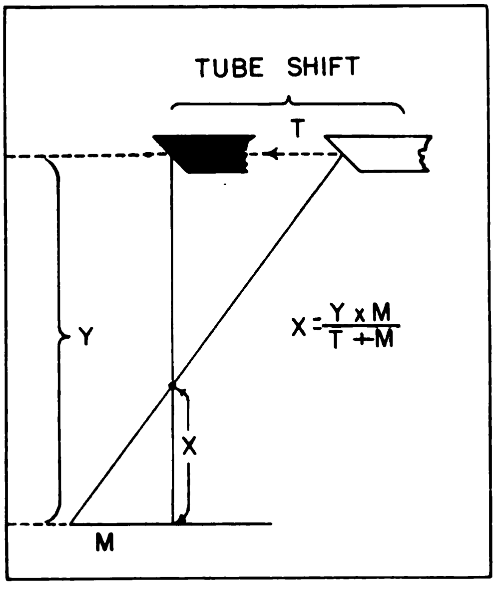
**Two "D's" are needed to replace the two "Y's".

12. **Page 170 - In diagram, substitute "D" for "Y" - "D" for "Y".

$$T : M :: D\text{-}X : X$$
$$TX = M\,(D\text{-}X)$$
$$TX = DM\text{-}MX$$
$$TX+MX = DM$$
$$X\,(T+M) = DM$$
$$X = \frac{DM}{T+M}$$

Thus if we have an anode film distance of 30 inches, tube shift of 5 inches and image shift of 1 inch, we have:

$$X = \frac{30 \times 1}{5 + 1} = \frac{30}{6} = 5 \text{ inches.}$$



If radiography is used, two views are made on one film, the tube being shifted a convenient number of inches between each exposure enough to obtain a fair image shift. M.A.S. should be reduced to avoid excessive density; ordinarily it is best to use 1/2 the usual M.A.S. for each of the two exposures.

If fluoroscopy is used it will be best to mark each image position on the underlying skin with a fountain pen, indelible pencil or grease pencil. The midpoint between the marks will be directly over the foreign body.

Another localization at right angles will improve accuracy. One of the localizations should be over the area through which the operative approach to the foreign body is to be made.

There are numerous adaptations of the triangulation principle and certain units have special mechanisms for the purpose. Naturally if a number of factors are fixed, tables can be prepared so that the depth of a foreign body can be ascertained from the image shift without the trouble of calculation. With some of these

methods the fluoroscopic screen must remain fixed while the tube moves, and so many fluoroscopic units will not be suitable. If one has a special apparatus to work with or contrives one, it is necessary to become thoroughly familiar with it and study any instructions with care. (See also Army field unit).

Further, it is a good idea to practice depth determination by means of some contrivance such as a box of rice (rice Phantom) in which it is possible to place suitable fragments of metal at any depth desired.

5. Foreign Bodies in the Eye:

Special methods are used for this type of localization.

The Contact Lens Method (Pfeiffer's modification) is not difficult of application and yields good results. It employs a contact lens containing four opaque marks near its periphery. The lens is slipped into place over the cornea by means of a suction cup device after sensitivity of the eye is dulled by a local anesthetic such as pontocain 1/2%. The upper and lower dots should be in the vertical plane and the other two in the horizontal. Radiographs are made in exact P.A. and Lateral projections through the orbit of the affected eye. The data from the radiographs are applied to special charts and the exact position of the foreign body determined.

A. Radiography, further details.

For convenience a right angle cassette tunnel is used, by means of which it is a simple matter to obtain the radiographs. A four-inch extension cylinder is best for radiography and a 36 inch anode film distance is excellent. The cassette size is $6\frac{1}{2}$ x $8\frac{1}{2}$ inches (8 x 10 films can be easily cut to $6\frac{1}{2}$ by 8 size which will answer well enough). Definition screens should be used and absolute cleanliness and freedom from lint are very real necessities for obvious reasons. The technician should also remember that definition screens are about 25% slower than the par speed screens.

The patient is positioned with the sagittal plane accurately horizontal, the injured eye down and the head closely applied to the vertical section in the nose chin position. The patient's eyes should be directly in line with two openings provided to make inspection possible. An adjustable "bite bar" is attached and aids in immobilization. Position remains unchanged for both lateral and vertical views, adjustment being by appropriate arrangement of the X-ray tube. The patient should be instructed to look straight forward and keep the eyes and eyelids motionless during exposure.

Occasionally it may be found helpful to make additional views with the patient looking up and again looking down. In this case careful identification of films is essential. When satisfactory radiographs are obtained the lens is promptly removed.

B. Charting.

The P.A. film is placed so as to represent the patient facing examiner and

then:

1. A horizontal line is drawn just below the orbital ridges.

2. Connect the "dots" of the lens by a vertical and a horizontal line. The intersection of these lines naturally marks the middle of the lens and accordingly the optical axis.

3. A line is now drawn through the foreign body and the center point just determined. It should be extended to or beyond the orbital margin to facilitate measurements. It constitutes the meridian of the foreign body.

4. Measure the angle formed by this line with the horizontal line drawn as the first step. By use of this determination, the foreign body meridian can now be drawn on the first chart. (P.A. projection).

5. The distance between the center point (optical axis) and the foreign body is measured and, after the radiographic correction factor for distance is applied, marked on the chart at the proper place on the meridian line of the foreign body.

We are now ready for the lateral projection. It is placed so that the injured eye is nearest the observer and then:

6. A vertical line is drawn through the anterior border of the upper and lower dots to define the limbus or outer margin of the cornea.

7. A line is now drawn through the foreign body perpendicular to this vertical line and the distance between the foreign body and the vertical line measured, corrected and applied to the second chart (lateral or meridional section) on its main axis above the zero line.

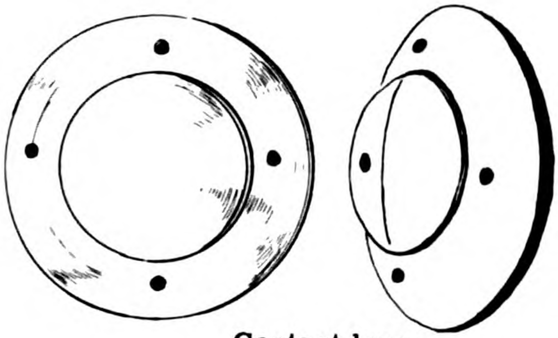
8. Intersecting lines are now drawn on this same chart (meridional) as follows: First a vertical line is drawn at the distance of the foreign body from the center as indicated in the first chart. Next a horizontal line is drawn at the distance of the foreign body from the limbus of the cornea as already marked on the main axis of this chart.

This intersection gives the position of the foreign body, indicating both depth from the limbus and distance from the optical axis.

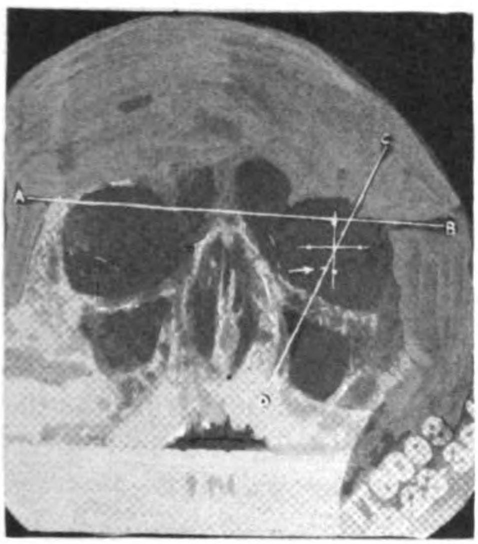
The correction factor is calculated by dividing the actual distance between the two dots (12 and 6 o'clock), as stamped on lid of case, by the distance as measured on the P.A. radiograph. It usually approximates 0.9.

In Sweet's method the affected eye is radiographed at two different angles in accurate relationship to two fixed objects. (Small metallic ball and cone supported on slender rods). The data derived from the radiographs are applied to special charts and the position of the foreign body determined.

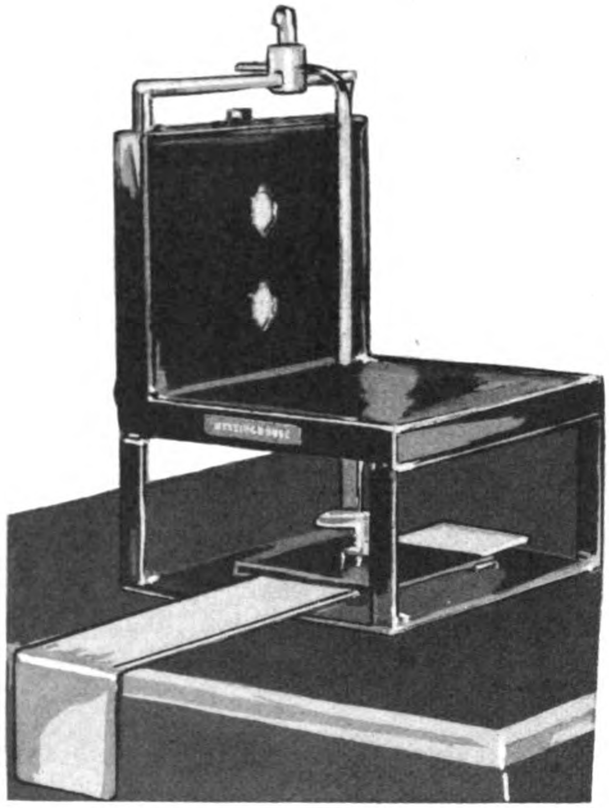
As a final point regarding foreign bodies, it should be remembered that careful soft-tissue technique will often be necessary for low density objects such as glass.



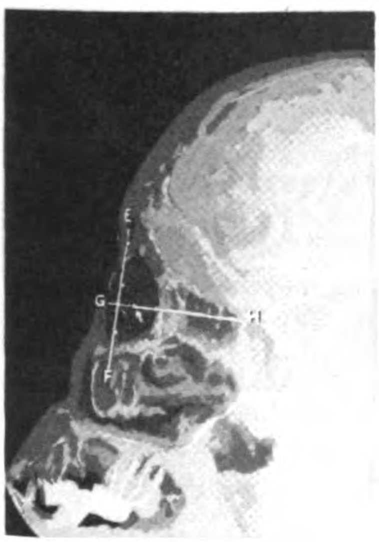
Contact lens



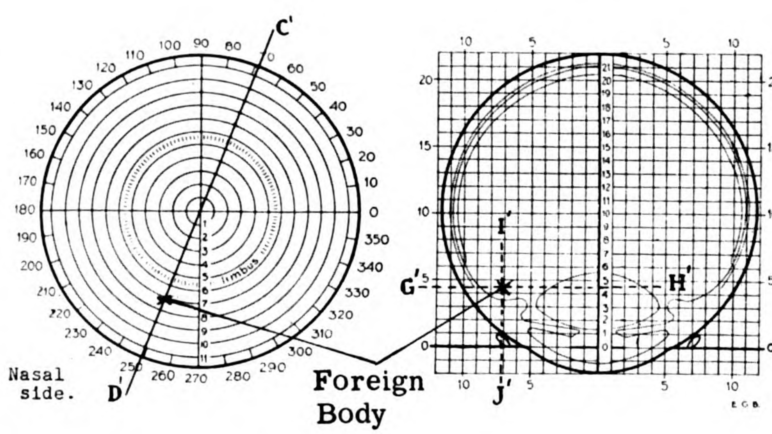
P. A. view



Pfeiffer stand



Lat. view



Localization chart

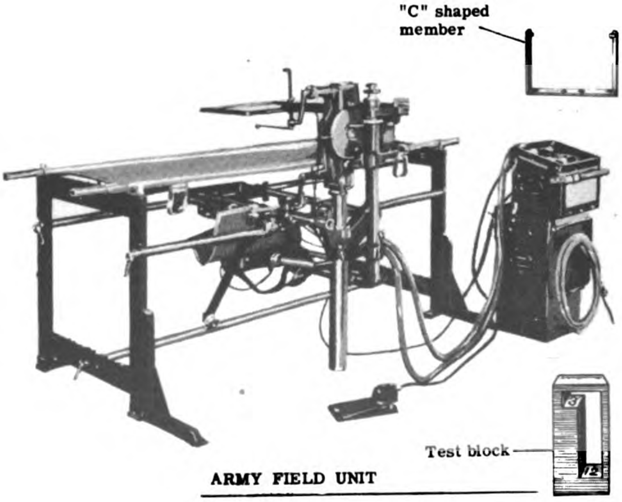
Fragments of wood or plastic substances seldom show unless paint has been present on them. (Zinc or Lead).

Notes on Equipment for Ships and use in the Field.

Units of various types are made use of depending on circumstances. Aboard many ships mobile units of 15 and 30 M.A. capacity are to be found. Other ships may have only a dental unit. Some of the smaller units are readily disassembled and can be easily transported and put to use where desired. The use of the various units involves no very special roentgenological problems other than modifying technique to suit the capacity of the units.

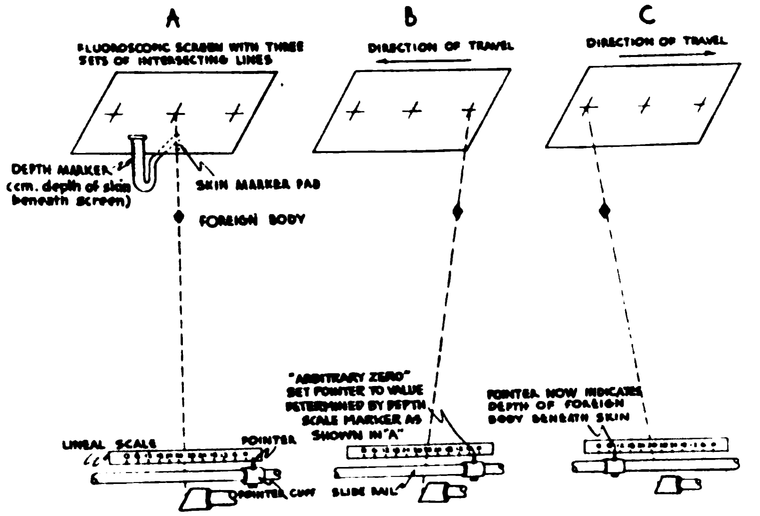
Wafer grids take the place of the Bucky or it may often be the case that neither type of grid will be available. In that case, the lack of a grid can be offset to a considerable extent by the careful use of cones. In the first views of a heavy part, it may be well to dispense with small cones or cylinders to get wide coverage. Such a film though sadly lacking in brilliance, will serve to locate injuries with precision. Thereafter coning can be sharp and will produce very satisfactory views, even of the lateral lumbar spine. As a matter of fact, the exposure for lateral lumbar views with the Bucky or wafer grid (usually 250 M.A.S.) is excessive for many small units, and so "spot shots" are definitely indicated. This means care and precision on the part of the technician. Reviews of anatomy and study of the skeleton when the opportunity presents should not be neglected. It is remarkable what can be done in the way of sharp spotting by one who knows his X-ray anatomy and has cultivated habits of precision. It is also remarkable how, when the reverse is the case, the party concerned proves unable, so to speak, to hit a barn door using a blunderbuss.

The army, in collaboration with X-ray engineers, has developed a rugged, versatile and readily transportable unit of good capacity and suitable for a variety of purposes. It is readily assembled or disassembled and packs into field chests. An attachment is provided for convenience in fluoroscopic localization of foreign bodies.



ARMY FIELD UNIT

PROCEDURE DIAGRAM



FOREIGN BODY LOCALIZATION

Before proceeding with localization of a foreign body at an unknown depth, place depth phantom in position and check measurements. If indicated, adjust reading level on depth scale marker (this level is adjustable to provide for variations in the position of the focal spots of one or another X-ray tube).

1. **Check fixation locks on "C-shaped" member; secure alignment of focal spot to center of fluoroscopic screen.**

2. **Align a prominence on foreign body to intersection of central intersecting lines.**

3. **Dampen skin marker pad with tincture of iodine or ink and adjust it to this alignment (foreign body and intersection of central intersecting lines): lower skin marker pad, until it rests on the skin, thereby marking it.**

4. **Read distance between fluoroscopic screen and skin by way of scale on depth marker (Figure "A").**

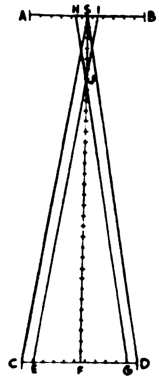
5. **Shift tube and fluoroscopic screen so as to align the same prominence of the foreign body, as considered in Step No. 2, to the intersection of either of the outer intersecting lines (Figure "B").**

6. **Slide localization scale and adjust pointer to the centimeter value coinciding with the centimeter distance between the fluoroscopic screen and the skin as measured in Step No. 4 above; clamp cuff for fixation of pointer to side rail of table.**

7. **Slide X-ray tube and fluoroscopic screen in direction opposite to that used in Step No. 5 above, until the same prominence on the foreign body becomes aligned to the intersection of the opposite outer intersecting lines (Figure "C").**

8. **Read on localization scale, the depth of foreign body beneath the skin.**

GEOMETRIC DETAILS



DISCUSSION OF DIAGRAM

1. A-B equals spacing between outer intersecting lines; it is equal to 22 cms.

2. F-S equals focal-screen distance (focal spot to intersection of central intersecting lines); it is equal to three times A-B, or 66 cms. (plus or minus minor deviations in the position of the focal-spot).

3. If a foreign body were located at S (i.e., just beneath the intersection of the central intersecting lines), for alignments of it to the intersection of the outer intersecting lines at A and then at B, the X-ray tube would have to be moved with the fluoroscopic screen for a distance equal to C-D. C-D equals A-B (i.e., 22 cms.) In the case of foreign bodies located at other levels below the plane A-B, the same ratio relationship would hold, that is the range of travel of the X-ray tube and fluoroscopic screen for the alignments of the foreign body with points A and B respectively would be 1/3 the distance F-J.

4. Since triangle E-J-G is similar to triangle J-H-I, the distance S-J bears the same ratio relationship to H-I as does J-F to E-G, that is, a three-to-one ratio.

5. H-I is equal to H-S plus S-I.

6. H-S equals G-D while S-I equals C-E; therefore, H-I equals C-E plus C-D; C-E plus G-D is the untraveled distance (22 cms. minus the distance of travel) which actually measures the location of the foreign body beneath the fluoroscopic screen.

7. The distance between the fluoroscopic screen to the skin is subtracted by making the adjustment of the pointer to an "Arbitrary Zero" as shown in diagram B and thereby the reading of the untraveled distance (as indicated on the localization scale) indicates the measurement of the foreign body beneath the skin level.

The tube stand arrangement makes possible vertical and horizontal fluoroscopy. The X-ray tube is of special design: It is shock-proof and has very efficient cooling mechanisms so that it will withstand continuous operation at low settings. Capacity of the machine is about 30 M.A. at 85 K.V.P.

Needless to say, in the case of any units that are to be transported about with the attendant setting-up and taking-down, the personnel in charge of them should become "letter perfect" in handling them. In emergency situations and under battle conditions, loss of time due to unfamiliarity with the appartus to be used, is unforgivable.

THERAPY

1. Quality of Radiation:

Roentgen therapy has been employed from the earliest days of X-ray and is becoming of ever increasing importance. The apparatus employed is also becoming more intricate and powerful. It is thus appropriate to give some account of the matter.

As a preliminary it should be definite, decided what factors are to be used taking into account the type and capacity of apparatus, inclusive of the tube and also the types of therapy to be given.

There are two main categories of therapy, superficial and deep; however, two additional categories are often employed, namely intermediate and super-voltage. Occasional use is made of very low voltage rays (less than 10,000), usually spoken of as "Grenz" rays.

Superficial therapy usually calls for a range of 85 to 100 kilovolts with filtration limited to 1 mm. of aluminum or possibly that inherent in the tube (equivalent to 1/2 mm. Al. for oil immersed tube). Distances commonly vary from 12 to 50 cms. A special contact tube of very high emission rate is sometimes used for very superficial lesions.

Intermediate therapy usually extends to about 140 K.V.P. and filtration is usually 3 to 5 mm. Al. or 1/4 mm. Cu. plus one mm. Al.

Deep therapy ordinarily calls for 200 K.V.P. with filtration of 3 to 5 mm. of Al. plus 1/2 to 1 mm. Cu. Combinations of tin, copper and aluminum are also used and form the so-called "Thoraeus" filters. These are very effective when maximum penetration is desired.

Super voltage therapy employs from 400 to 1,000 K.V.P. and is naturally employed for maximum depth effect. Filtration is again increased as for instance to 1mm. Sn. + 0.5 Cu. + 6 Al. in the case of a 400 K.V. machine.

In addition to the radiation that passes thru any filter, there is bound to be secondary radiation emanating from the filter itself and caused by the radiation which has been intercepted. This radiation will be in wave length bands characteristic of the element or material thru which Roentgen rays are passing. Thus the term

"characteristic radiation" is derived.

The characteristic radiation of the Al. is of such long wave length (or soft) that it is absorbed by a few cms. of air and, in practical therapeutics, can usually be disregarded. Thus the rule that when multiple filtration is used, part of the Al. filtration, at least, is placed nearest the patient.

If it is born in mind that the Roentgen ray produces its effect when it is stopped rather than when it passes thru it can be readily understood why different ranges of therapy are used. For skin effects we need radiation that will be absorbed as far as possible in the skin and superficial tissues; for deep effects we need radiation that will pass thru the skin and be absorbed in the deep tissues.

In practice it works out about as follows: With superficial therapy, about 10% of the radiation will reach a tissue depth of 10 cms.; with intermediate therapy roughly 20% should reach a 10 cm. depth; with deep therapy the 10 cm. depth dose will approximate 30 to 40% and with super voltage 50%. These figures are subject to considerable variation depending on the size of port used and other factors, but will serve to give a rough idea of what may be expected. (% based on skin dose).

In order to indicate the quality of radiation used in therapy, various systems and terms are employed and the technician should know something about them. The kilovoltage and other factors alone are not sufficient; nor is the dosage in "r" units, as this figure tells us nothing about the quality or penetration of the radiation.

As already indicated, the shorter the wave length the greater the penetration. However, the X-ray beam from the usual therapeutic apparatus is never of a single wave-length but encompasses a more or less wide band and so constitutes a beam of heterogenous radiation rather than homogeneous. To get around this difficulty we can compare this heterogenous beam with a more homogeneous beam as to absorption in copper and other material as from a special constant potential generator.

Necessarily a given wave length of the homogeneous radiation will show a certain percentage of absorption in a given amount of copper. A heterogenous beam showing the same percentage of absorption can for practical purposes be said to have the same effective wave length and accordingly is so-called. The Greek letter Lambda (λ) is used to designate wave length.

In the actual charts the curves tend to be steep, and accordingly it is frequently an advantage to plot the logarithms of the percentages of radiation transmitted against a thickness of copper rather than to employ the percentages themselves. Thus in many charts, in place of 100%, there will be the number 2.0 and so on down the scale.

Designation of X-ray quality by effective wave length is in fairly common use but lately it is becoming more customary to use the "Half Value Layer" to designate quality. Moreover, this is the official method recommended by the committee of Standardization of X-ray measurements. This term is very simply defined as the thickness of a given material needed to reduce radiation 50%. Naturally the more penetrating the X-ray, the greater the half value layer will be. In the case of low

voltage, lightly filtered or "soft" types of radiation it is customary to use Aluminum; organic materials such as cellophane may be used for very "soft" radiation. For the more penetrating radiation, Copper is in general use.

In determining the half value layer, observe the following precautions and proceed as follows:

1. Measure all distances accurately and use stop watch for timing.

2. Suspend the ionization thimble in free air and away from any objects which might set up measurable radiation.

3. It is well to limit the beam to a size only slightly greater than the ionization chamber.

4. It is good practice to make initial readings without the filter material to be used in the test, averaging at least three consistent readings. (Large discrepancies in readings signify faulty technique or apparatus and naturally calls for investigation and appropriate action).

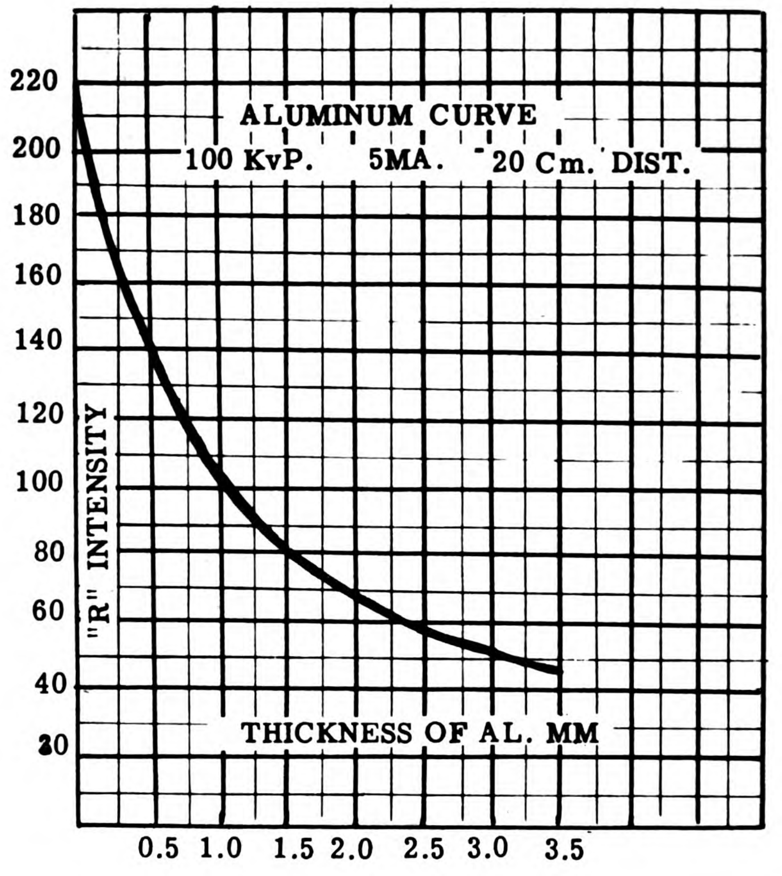
5. Make a series of readings with various thickness (usually six) of the material in which the half value layer is to be determined. The thicknesses and type of material used should naturally be picked with reference to the type of radiation to be tested.

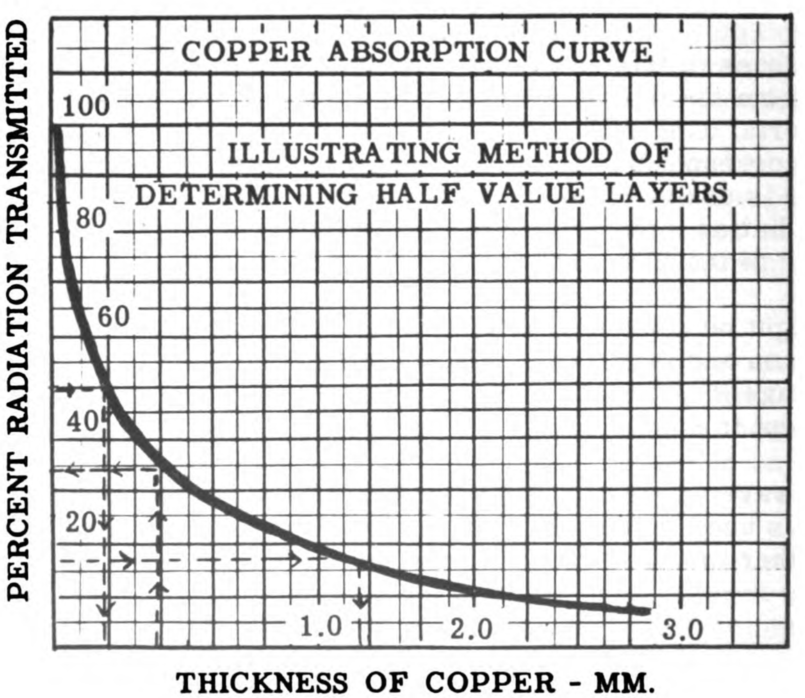
6. A curve is now laid out with the intensity of the X-ray transmitted, plotted against the corresponding thicknesses of the material. The intensity can be recorded directly in "r" units or percentage.

By means of this curve the half value layer can be determined for the initial radiation from the tube and for the radiation as filtered through various thicknesses of the material used within the limits of the chart. One simply marks off a point on the curve corresponding to the intensity for the filtration factor for which the half value layer is desired; then pick off a second point on the curve corresponding to half the radiation intensity designated by the first point. The difference in the two thicknesses of the filter material is naturally the half value layer.

It might be noted here that with the lower voltage ranges one will do well to use aluminum and increase it either a quarter or a half mm. per step. With the higher voltage it is best to use copper, increasing thicknesses a quarter mm. at a time. (Except in super voltage machines where the steps should naturally be greater).

The wave length of characteristic radiation becomes shorter as the density of materials used increases. Hence, the most dense element is placed nearest the tube and other materials follow in order, e.g.: Pb. - Sn. - Cu. - Al.





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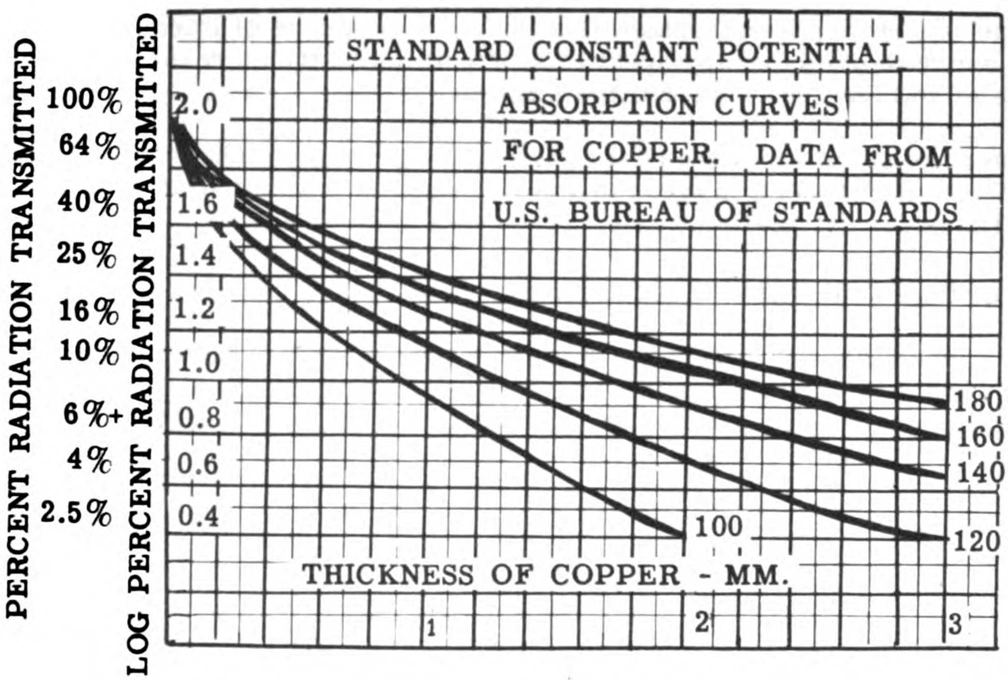


RELATION OF VARIOUS FACTORS TO DEPTH INTENSITY
(Port 20 x 20 cm.; T. S. Dist. 50 cm.)

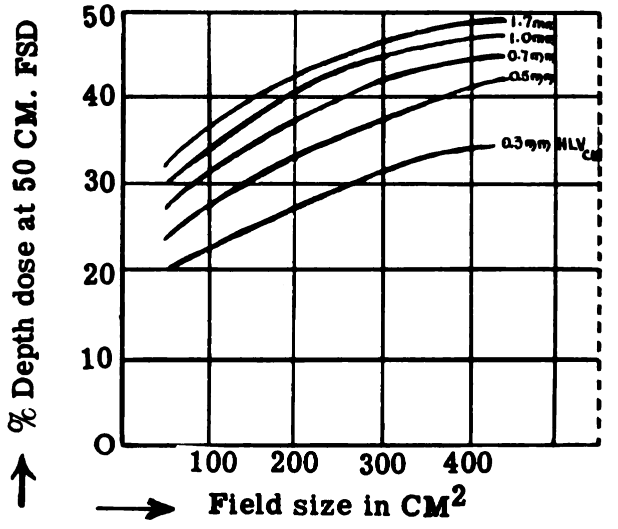
Kv. (Peak)	Filter mm.	H.V.L. mm.	Effective wave length in A.U.	Approximate Depth Intensity at 10 cm.	
				Percentage air intensity	Percentage skin intensity
100	Inherent	0.8 Al.	.6	14	12
120	1.0 Al.	0.17 Cu. (3.7 Al.)	.34	30	23
140	0.25 Cu. + 1 Al.	0.53 Cu. (9.0 Al.)	.21	50	33
200	0.5 Cu. + 3 Al.	1.2 Cu. (14.0 Al.)	.14	58	38
200	1 Cu. + 3 Al.	1.6 Cu. (16.0 Al.)	.11	60	43
400	0.4 Sn. + 0.25 Cu. + 6.0 Al.	3.6 Cu.	.073	64	48

The 10 cm. depth percentage is a practical measure of intensity and is in general use with deep therapy apparatus. Depth intensity increases markedly with increase in voltage and heavier filtration.

There is some variation in the figures found in the various tables and charts. This reflects differences in types of tubes, generators and instruments used, as well as bases for calculation.

2. <u>Determination of Quantity of Radiation:</u>

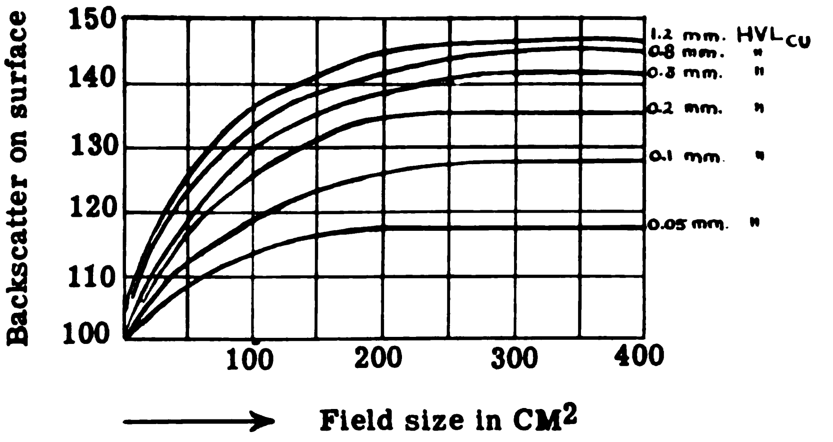
In connection with preceding table it is necessary to bear in mind that when smaller ports are used the depth dosage will decrease, due probably to a lessened amount of secondary radiation in the tissues. The following chart will serve to indicate the relationship.



EFFECT OF FIELD SIZE ON 10 cm. DEPTH INTENSITY

The secondary radiation in the tissue scatters and adds to the radiation directly received from the original beam. As a result, the skin dosage will be more than the dosage as measured in free air. This increase is spoken of as "back scatter". It increases with the size of the port just as depth dosage. It also increases within limits as the penetration increases. There is little change after a quality of 1 mm. of copper half value layer (H.V.L. $_{Cu.}$ = 1 mm.) is reached.

The following chart indicates the relationship between back scatter and size of port.



EFFECT OF FIELD SIZE ON BACK SCATTER.

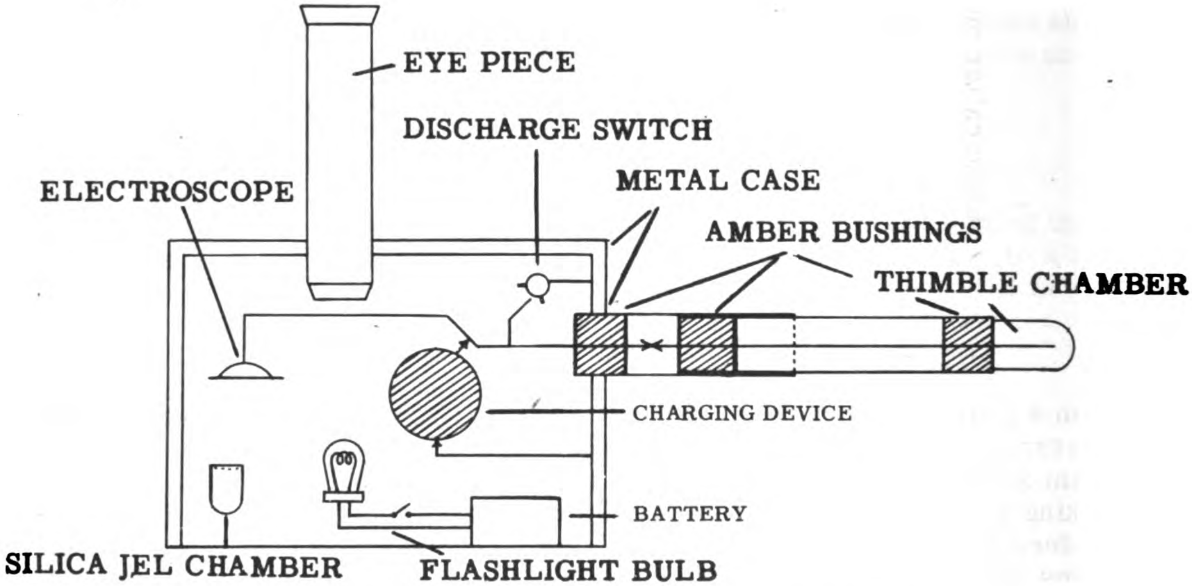
From a practical standpoint, the back scatter in superficial therapy seldom needs concern us. In the case of deep therapy, the back scatter increases the skin dosage from about 20% for small ports up to almost 50% for large ports under usual working conditions. Thus when speaking of dosage applied to the skin in the course of deep therapy discrepancy is possible. It is probably best to report dosage in terms of the amount as measured in free air at the skin surface, indicating that such is the case and realizing that the actual skin dosage is in excess of this amount. The same condition applies in calculating depth dosage as the percentage will differ according to whether it is based on actual skin dosage or the air dosage at skin level as indicated in the table just given.

In practical work employing deep therapy, many cases call for treatment to limits of tolerance. Due to recovery powers of the skin a large total (several times the erythema dose) can be given without undue damage by fractionating the total dosage so that each individual dose is below the erythema level. Recovery of the skin amounts to about two thirds after 24 hours.

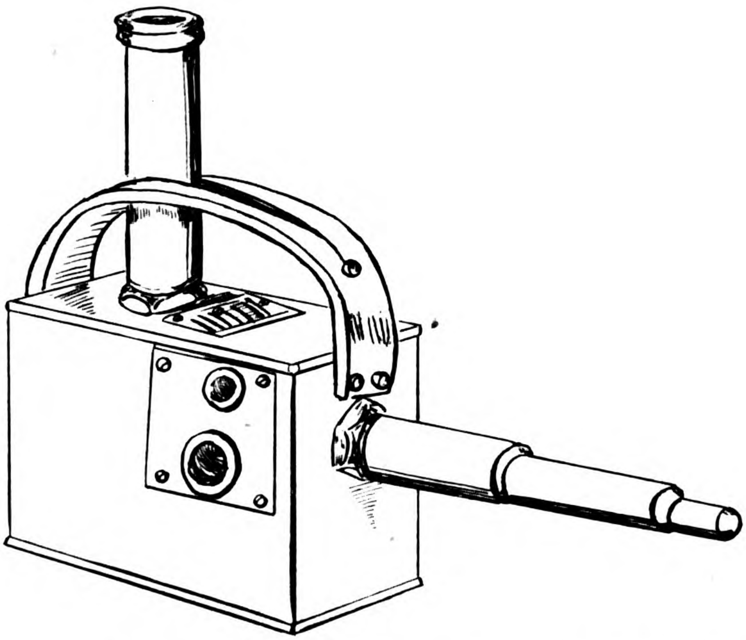
Small or moderate uniform dosage, once or perhaps twice daily over a protracted period, characterizes the "Coutard" technique. The saturation technique calls for rapid delivery of an erythema dose to the affected tissue and then maintaining the effect by additional smaller doses. Again for certain types of diseases some workers like to irradiate the entire body, naturally with small doses.

The preceding discussion has dealt with relative intensities. It is necessary now to take up the matter of specific units used in measurement. In the past numerous methods were used, all of which were more or less unsatisfactory. Finally, in comparatively recent years, it was found possible to employ the ionization principle in a practical device called the Victoreen "r" Meter. The term "r" refers to the unit of therapy or "Roentgen" unit. It is defined as that amount of radiation which, when primary and deflected (or secondary) radiations are both used, will produce in one (1) cc. of air under standard conditions, one electrostatic unit of

charge or 1/3000 microcoulomb. About 300 "r" constitutes an erythema dose for superficial therapy.



SCHEMATIC DIAGRAM OF VICTOREEN "r" METER



THE VICTOREEN CONDENSER "r" METER

Victoreen "r" Meter:

This is a delicate instrument but not difficult to use. Instructions must be studied carefully and carried out to the letter. This meter must be handled gently and stored in a safe dry place. The batteries should be removed if the instrument is to be stored for more than a few days.

The desiccator chamber in the bottom of the case is partially filled with silica gel which does not become liquified upon saturation. When the crystals turn pale pink either replace the contents or remove desiccator and dry in oven at 300° F. (149° C.) which will restore blue color. Allow to cool before reinserting into gasket.

The unit should be recalibrated at the factory every 6 - 12 months.

The operation depends on the effect of ionization on an electric charge.

A small ionization chamber or "thimble" borne on a special carrier is subjected to X-ray and its contained air thus ionized to a degree dependent on the amount of X-ray received. This thimble is then connected to an insulated chamber which has received a measured charge recorded by the electroscopic device. The result is that the charge will be reduced to a measurable extent by the conductance offered by the ionized air in the thimble. The reduction in charge thus harks back to the amount of X-ray used on the thimble and accordingly the scale used in measuring the decrease in charge can be and is calibrated in terms of "r" units. A double scale is provided, 0 - 25 and 0 - 250 depending on the size of the thimble used.

Calibration hardly ever comes out in even terms, the result is when you wish to give the patient a specified dosage, calculations are involved. Since dosages are commonly prescribed in even numbers such as 50 - 100 - etc., it is very convenient to prepare a table from which the proper time can be read directly for such dosages under various conditions. This procedure will also prevent the need for hurried calculations, which needless to say, are apt to be a source of error.

It is common to speak of the skin erythema dose and this used to be one of the regular units employed and in any event it is still necessary to know the relationship of "r" units to an erythema dose. This is not a simple matter in that different qualities of radiation differ in effect and the skin of different individuals varies enormously in response.

It may be said that from 250 to 350 "r" units will constitute an erythema dose with superficial types of radiation, lightly filtered or perhaps unfiltered. In the case of heavily filtered radiation, 500 to 750 "r" units will usually constitute the threshold erythema dose. Furthermore, deep therapy rays have a tendency to produce more tanning than superficial rays and in cases of heavy exposure, less tendency to favor remote harmful effects such as telangiectases (infiltration of the skin with small dilated capillaries).

SAMPLE THERAPY TABLES

K.V.P.	100	100	100	100	100	100	100	100
M.A.	5	5	5	5	5	5	5	5
Dist.	12.5	12.5	20	20	20	25	25	35
Filter-mm.	0	1 Al.	0	1 Al.	3 Al.	0	1 Al.	0
R/Min.	420	215	180	84	43	110	55	53
R Units Dose 50	0: 7	0: 14	0: 17	00: 36	1: 10	0: 27	0: 55	0: 58
75	0: 11	0: 21	0: 26	0: 54	1: 45	0: 40	1: 23	1: 27
100	0: 14	0: 28	0: 34	1: 12	2: 20	0: 54	1: 50	1: 56
150	0: 21	0: 42	0: 42	1: 48	3: 30	1: 20	2: 46	2: 54
500	1: 11	2: 22	2: 50	6: 00	11: 40			
750	1: 47	3: 30	4: 15	8: 05	17: 30			
1000	2: 23	4: 40	5: 40	12: 00	23: 20			

K.V.P.	200	200
M.A.	20	20
Dist.	60	60
Filter-mm.	.5 Cu. 3 Al.	1 Cu. 4 Al.
R/Min.	40	26
R Units Dose 50	1: 15	1: 55
60	1: 30	2: 21
75	1: 45	2: 54
100	2: 30	3: 54
150	3: 45	5: 49
200	5: 00	7: 48
300	7: 30	11: 42
400	10: 00	15: 36
500	12: 30	19: 30

Note: These tables apply only to the particular units for which they were prepared.

In terms of radiation factors, only a very rough idea of "r" unit output can be given because it will differ with different machines to a considerable extent even though physical factors are the same. Thus the importance of calibration with the r-Meter. At 100 K.V.P., 5 M.A., 30 cm. distance and no filter other than the inherent (0.5 Al.) output might roughly approximate 100 r.p.m. At 65 K.V.P., 5 M.A. and 30 cm., without filter, output might be roughly about 60 r.p.m. This would approximate the factors obtained from a dental unit. Such a unit might answer for aiding in the treatment of infection in a dangerous location such as cellulitis or furuncles near the nose and mouth; and in emergency, exposures of about a minute (with interruptions for cooling every 15 seconds) at the 12 inch distance and employing 5 M.A., would be justifiable, as even gross errors would not exceed tolerance. Such exposure would result in 300 M.A.S. at 12 inches, with 65 K.V.P. Safe tolerance in terms of physical factors, and incorporating a wide margin of safety, permits 380 M.A.S. at 85 K.V.P. (At 65 K.V.P. the permissible M.A.S. should approximate 550-600).

Needless to say, calibration of dental or other units aboard ship should be carried out at the first opportunity. Hospital ships and naval hospitals are usually able to help. These small units should not be used for treating anything but truly urgent cases.

Since occasional mention is made of older units of dosage, the following table is included for reference purposes.

TABLE OF OLD UNITS

UNIT	DEFINITION	REMARKS
Skin Unit	Erythema from superficial therapy (McKee) based on formula: $\frac{MA \times (Kv)^2 \times \text{Time in min.}}{(\text{Distance in inches})^2} = 960$	Formula was very useful. Equivalent to 300 "r".
HED	Based on mild erythema and temporary pigmentation. (Seitz and Wintz -"Hauteinheitsdosis").	Equivalent to about 550 "r".
S - N	Erythema dose (Sabouraud-Noire).	Based on discoloration of Barium platino-cyanide.
H	One fifth Erythema dose (Holzknecht).	5 H = 1 S - N
X	One tenth Erythema dose (Kienbock).	10 X = 5 H = 1 S - N (Superficial therapy only).
e	170 e equals Erythema dose (Friedrich & Kronig).	Approximates 600 "r". (Deep therapy).
E	Electrostatic unit (Duane).	Value approximately same as a Roentgen.
R-French	Based on ionization produced by Radium. (Solomon).	Mean value about 2.5 "r".

Therapy Tubes:

The general construction of therapy tubes follows the same general pattern of radiographic tubes. There are, however, several differences depending largely on the fact that these tubes are operated continuously for long periods and at relatively high potentials. Thus, these tubes have special problems with regards to heat dispersal, insulation and high potential stresses. The old Coolidge universal tubes could withstand continuous exposure at levels below 100 K.V.P. and 5 M.A. without special cooling devices. The usual oil immersed shockproof tubes will not do this. Accordingly for therapy upto 140 Kv. most tube assemblies are cooled by running water which is turned on automatically by means of a relay when the main X-ray switch is closed; or oil circulation may be combined with a forced draft of air applied to the anode end of the assembly as is done in the X-ray tube of the Army Field Unit. In the case of deep therapy tubes, cooling is usually accomplished by circulating oil which, after leaving the tube head, passes through water-cooled coils. Again the tube head may be exceptionally large and so contain sufficient oil that

cooling can be accomplished merely by circulating the oil in the head.

With regard to electrical stresses, these are such that, in case of potentials exceeding 140 K.V.P., the entire load should not be thrown on the tube at once. In most therapy circuits there is a rheostat so connected that the high tension circuit cannot be closed unless all the rheostat resistance is "in". This resistance should be gradually reduced step by step as the tube warms up. It may also be necessary to do this with several autotransformer settings before the full operating potential is reached. In general, when the tube is cold one should start at 140 K.V.P. and bring the tube to the operating range in about 10 or 15 minutes; several minutes will answer when the tube has been used within the past hour. Unsteady operation of the tube during the "warm up" period, is an indication that the load is being increased too rapidly. Autotransformer settings should be so selected that when the desired K.V.P. is attained, most of the rheostat resistance will be out of the circuit.

Unless a time delay relay is present to keep the cooling apparatus functioning for a proper length of time after the machine has been shut off, it is necessary that the operator take care of this himself - that is, he must keep the main switch closed for at least a full minute after the high tension is off. Otherwise there will be undue accumulation of heat at the anode, thereby endangering the tube.

Never change autotransformer settings while the tube is in operation. The resultant arcing at the autotransformer studs will cause trouble sooner or later.

Do not leave the controls while the tube is in operation.

Keep an eye on cooling devices.

Radium:

The use of radium in treatment is closely allied to roentgen therapy. This is because its chief therapeutic effects depend on the Gamma ray which is identical with the X-ray except that it is of still shorter wave length (0.017 A.U. - H.V.L. 14 mm. Pb.).

The atom of radium is unstable and breaks down with the eventual formation of three rays designated Alpha, Beta and Gamma. The Alpha rays are helium atoms minus 2 electrons and so are positively charged. Beta rays are made up of electrons. Gamma rays, as noted, resemble X-rays.

Radium is one of a series of radioactive elements starting with uranium and ending in Radium G or lead. Radium itself disintegrates slowly so that 1680 years are needed to reduce a given quantity by 1/2. Its first disintegration product, radium emanation or radon, decays in a few days and is the source of the potent Gamma rays effective in Radium therapy. It is a gas and so can be placed,for instance,in gold "seeds" and implanted in tissues. Radium itself can be applied in tubes, molds "packs", needles and again on applicators of various sizes and shapes. Its Gamma ray has great penetrating power and platinum or gold (Pt. and Au. respectively) are used as filters sometimes supplemented by brass or steel.

The exposure for radium or radon is stated in terms of mg.-hr. (milligram-hour) or mc.-hr. (millicurie-hour). The term "millicurie destroyed" is also used (mc. δ). Its value is 133 mg.-hr.

Comparison with Roentgen ray is somewhat difficult as the characteristics are different and the "r" output not known with sufficient accuracy. The following however will give some idea of comparative figures. The erythema dose of Gamma radiation is put at about 1,000 "r". To obtain this much radiation, we can use for instance:

(a) 2 cm. circular Radium applicator, at 1 cm. distance equals 234 mc.-hr. with filtration of 2mm. brass and 2.4 mm. rubber.

(b) 10 cm. diameter Radium pack (4.0 gms.), 6 cm. distance from surface calls for 12,000 mg.hr. for a threshold erythema with 0.35 Pt. and 1.5 mm. brass filtration. As an example of actual therapy, one might well call for 6,000 mg.-hr. daily alternating between two ports for cross fire effect until 36,000 mg.-hr. are given to each port.

(c) 14 mm. tube of Radon on skin requires 3 mg.-hr. unfiltered for erythema; at 2 cm. 7.5 mg.-hr. are required. If 0.5 mm. brass filter is used plus 1.2 mm. of rubber the dose will be 250 mg.-hr.

(d) In the case of gold seeds, a Radon seed 3 mm. long with 0.3 mm. gold filtration is said to produce an erythema in 106.4 mg.-hr.

As a final note it is important to state that in recent years it has been found that the Alpha ray has marked curative powers in cases of dermatitis and ulceration resulting from long continued or heavy dosage of Roentgen and Gamma rays and also from other causes. Radon is incorporated in an ointment base and in this manner Alpha ray therapy is made easy. The armed services now have access to this material from the Canadian Radium and Uranium Corporation, Rockefeller Center, New York.

ELECTRICAL AND X-RAY SAFEGUARDS

Modern apparatus has been rendered much less hazardous in many ways by the improvements of recent years. Tubes are "ray-proof" which means that there is no radiation except from the aperture beneath the anode. Most tubes are oil-immersed and "shock-proof" due to the provision of a grounded metal housing. Cables are likewise rendered shock-proof by efficient insulation which in turn is sheathed by grounded metal braiding.

However, numerous machines employing non-shock-proof open-bowl tubes and ordinary high tension wires are still in use. Secondary radiation is always present and if one is thoughtless it is not at all difficult to step into the path of direct radiation. Thus it is quite easy to acquire an excessive amount of radiation and moreover its effects are insidious and may not become apparent until after some years. Therefore, it is the part of wisdom to learn and follow all the necessary precautions.

An attitude of wholesome respect should be cultivated toward electric currents and X-rays. Always think of X-ray as an irritant which in sufficient amount will do great harm even to the point of fatality.

Electrical Safeguards:

1. Main and supply switches should be clearly marked. A pilot light is a good measure.

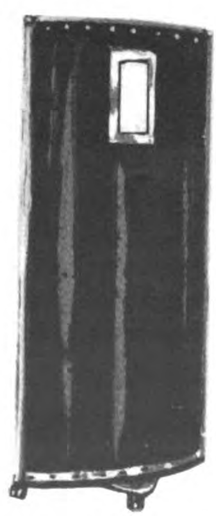
2. Push buttons and foot switches should be guarded or placed so that accidental closure will not occur. When several push buttons are present, each should be clearly identified by legible markings.

3. Push buttons, foot switches and the various regulating dials should not be tampered with until one is certain as to their functions.

4. Control stands, tube stands and X-ray tables should be grounded.

5. In the case of non-shock-proof apparatus it is necessary that a keen eye be kept on the patient and any attendants. No part of the patient, inclusive of wearing apparel, should come closer than a foot from the high tension wires and attendants should be duly cautioned especially when they have to help manage difficult cases such as small children and infants.

Lead-rubber gloves.



Protective screen with lead-glass window.

Lead-rubber apron.

6. Transformer rooms should be provided with safety switches which will prevent current flow as long as the door to the room is open.

7. Do not allow the presence of safety devices to make you reckless. Ground connections may be broken, safety switches may stick and insulation may breakdown.

8. Before inspecting any high tension apparatus furnished with condensers, ground out any charge by touching a wire to condenser and ground. Enough residual charge may remain on a condenser for fifteen minutes or longer after it has been in use, to give a disagreeable shock.

9. Be sure the circuit breaker is in good condition and if it is adjustable type be sure that it is set properly for the load.

10. When working on the machine take measures to insure that no unauthorized persons are loitering about the control room.

11. Whenever the X-ray apparatus is left unattended as at the close of the days work, during lunch periods, fire drills, etc., the main supply switch should be opened.

12. Never forget that if you are sufficiently well "grounded" as by damp hands or wet shoes, the ordinary 110 volt line current can prove fatal.

13. Sparking must be prevented when anesthetics such as ether and cylopropane are used. Thus units employed in the operating room must be shock-proof and connected by "explosion-proof" plugs.

X-ray Precautions with Notes on Biological Effects:

These fall into three divisions: (a) Safeguards for the patient; (b) Safeguards for people stationed in the vicinity of X-ray apparatus; and (c) Safeguards for the operator of X-ray equipment.

(a) Protection of the patient:

This has to do largely with the amount of radiation that may be safely used. This has already been mentioned in connection with fluoroscopy where safe limits were noted for a 12 inch distance between patient and target. A 10 inch distance is considered an absolute minimum for fluoroscopy. A table of safe M.A.S. values for various distances and filter values is given below. In addition to these maximum values it is also necessary to bear in mind that X-rays have cumulative effects. Thus exposure records should be kept preferably using a card as illustrated previously. When any given part has been given a maximum amount of radiation within a few days time, no further exposure should be made over this area for three weeks. This is particularly important in the case of the head. The patient who loses his or her hair as the result of injudicious X-ray exposure will assuredly not feel grateful. It is a good idea to post a chart of the exposure limits in a conspicuous place. It might be noted here that figures from different sources vary slightly but are in general agreement. The table given below is based on operation at 85 K.V.P. At lower kilovoltages, exposure limits will be increased, and at higher, decreased.

Kv	CHANGE IN MAXIMUM PERMISSIBLE EXPOSURE VALUES
100	Reduce by 25%
90	Reduce by 8%
85	No Change
80	Increase by 10%
70	Increase by 35%
60	Increase by 80%

MAXIMUM M.A.S. FOR THE HEAD

Target-Skin Distance Inches	Filter - mm. Al. External - None Inherent - 0.5 Total - 0.5	Filter - mm. Al. External - 0.5 Inherent - 0.5 Total - 1.0	Filter - mm.Al. External - 1.0 Inherent - 0.5 Total - 1.5
10	200	380	610
12	290	550	875
14	390	750	1190
16	510	970	1560
18	650	1240	1980
20	800	1530	2450
22	960	1840	2970
24	1150	2150	3540

MAXIMUM M.A.S. FOR OTHER PARTS

Target-Skin Distance Inches	Filter - mm. Al. External - None Inherent - 0.5 Total - 0.5	Filter - mm. Al. External - 0.5 Inherent - 0.5 Total - 1.0	Filter - mm.Al. External - 1.0 Inherent - 0.5 Total - 1.5
10	265	510	810
12	380	730	1090
14	520	1000	1500
16	680	1300	1950
18	870	1650	2500
20	1060	2050	3000
22	1280	2450	3640
24	1530	2900	4360

In view of the above tables it may seem that the figures mentioned in the chart of fluoroscopic precautions (768 M.A.S. at 12 ins. and for 75 K.V.P.) are unduly conservative. Nevertheless it is best to err on the side of safety. There is a tendency for the M.A. to creep up or to be increased and there is a tendency to forget about time, especially in a difficult orthopedic case where in addition the radiation will

always be centered on the same place. The tube distance may also diminish. When the fluoroscopic field is shifted constantly as in examinations of the stomach and duodenum the situation permits of greater liberality. Under such circumstances a good rule is limit exposure to a total of 8 minutes at 3 M.A. and 75 K.V.P. or 5 minutes if a 5 M.A. current is used.

As indicated by the table, the filter of 0.5 or 1 Al. is of the greatest importance. Never omit it.

In the case of X-ray therapy, precautions are of different type. Here certain dosages are prescribed by the roentgenologist involving variables such as K.V.P., filtration, target-skin distance, size and shape of areas treated, time, M.A., number and spacing of treatments. The technician called upon to aid the radiologist in administration of therapy bears a weighty responsibility. The various factors just mentioned must be dealt with accurately and forgetfulness is almost certain to entail the most grave consequences. The reason for this lies in the biological effects of X-ray and the technician should know something of this just as the apothecary should know drugs.

At the basis we have electro-chemical changes in cells resulting from the ionization due to exposure to the Roentgen ray. These tissue changes up to a certain point are reversible or at least recoverable from in whole or large part. Beyond this point they are not and accordingly cells so irradiated are permanently injured and often die. Thus the X-ray should be thought of as an irritant which in large doses becomes caustic and lethal. Therapeutically the irritation in proper amounts often leads to beneficial reactions and at times lethal effects are desired as in the case of certain tumors.

Just as some parts of the body are more sensitive to chemical irritation than others, so the tissues vary in sensitivity to the X-ray. In general the most active cells are most readily affected probably because such cells contain more unstable compounds susceptible to changes consequent upon ionization effects. A cell in resting or inert state is less vulnerable, as is in keeping with the general behavior of cells. Thus for instance spores and encysted organisms withstand severe injury, even at times to prolonged boiling whereas the active or vegetative cells ordinarily succumb to moderate injury.

Since a cell is probably most active when about to divide (mitosis) it can be readily understood that the blood forming cells and gonads are high on the list of sensitivity. Thus one of the first signs of too much exposure to X-ray is a fall in the blood count, the white cells first and later the red cells, this order being due probably to the fact that the life span of the white corpuscles is considerably less than that of the red. Thus too, the well known fact that the Roentgen ray can cause sterility.

It can also be readily grasped that the hair follicles, the germinal layers of skin and the growth centers in the bones of children are readily affected by excessive radiation. Active glands of all description are influenced, also the blood vessels, this last feature making for eventual impairment of circulation in tissue severely damaged by X-ray.

A pecularity of X-ray is that its effects come on much more gradually than the effects of other radiation. Erythema from X-ray usually reaches a maximum in a week to 10 days. Atrophy, chronic dermatitis and ulceration, such as may result from excessive exposure, often develops in the course of years. These effects are most pronounced with "soft" unfiltered radiation of long wave length and are minimized by high voltage, heavily filtered, radiation of short wave length. Hence, the use of 200 to 600 K.V.P. machines for deep radiation and the interest and experimental work on machines of 1,000 and even greater K.V.P. capacity.

In general it should be apparent that the Roentgen ray is a potent but treacherous therapeutic agent and why the following precautions are so important.

The factor most apt to be a source of error is the filter, and so the filter should always be double checked. Omission of a filter may result in four fold increase in radiation or even more. Therapy machines are more and more being equipped with filter registers so the filtration will be indicated on the control panel and in addition these registers can be interconnected with the X-ray control circuit so that the machine will not function if filtration is not properly arranged. (The filter in the tube head must coincide with the one to which a dial on the control board is turned).

Distance must be measured accurately because of its great effect on radiation intensity. (Law of the inverse square).

Aside from these precautions the technician needs to bear in mind that no unauthorized treatments should be given; accurate records should be made; that the radiologist should always be consulted whenever there is the slightest doubt as to the handling of a case or the behaviour of the apparatus, that special dosimeters should be checked with an accurate stop watch or synchronous electric clock, that shielding is accurately accomplished; that no attendant is receiving an undue amount of radiation. The radiologist normally sees his cases practically every time they come in. However, the pressure of work and various demands on his time may not always permit of this. In that case the technical assistant should be alert to note the state of the patient and make inquiry if circumstances indicate such, so that he may keep the radiologist informed, particularly when anything appears amiss.

It is essential in all cases receiving therapy, that the prescription outlining the course to be followed, be completely written out so that there will be no mistake or misunderstanding. This is just as important in radiation therapy as the medical prescription is in the use of potent drugs and narcotics. To this end and for convenience in preserving records, it is best to have a regular form printed on a card. A sample form is illustrated below. In addition to such cards it is strongly urged that a regular work book be used, in which each patient is logged together with a note as to number of ports treated and dosage to each.

Finally it is worthy of note that in cases of chronic radiation dermatitis and ulceration that Radon ointment (Alpha Ray Therapy) is often very beneficial and is now readily procurable.

ROENTGEN THERAPY
U. S. NAVAL HOSPITAL, BETHESDA, MD.

Name____________ Status________ Date________ Request of:

Condition to be treated:____________ ____________ (MC), U.S.N.

____

Previous X-ray:________________________

Plan of treatment:________________________

____

Ports________ Size________ Dist.________ Shield________

K.V.P.________ M.A.________ Filter________

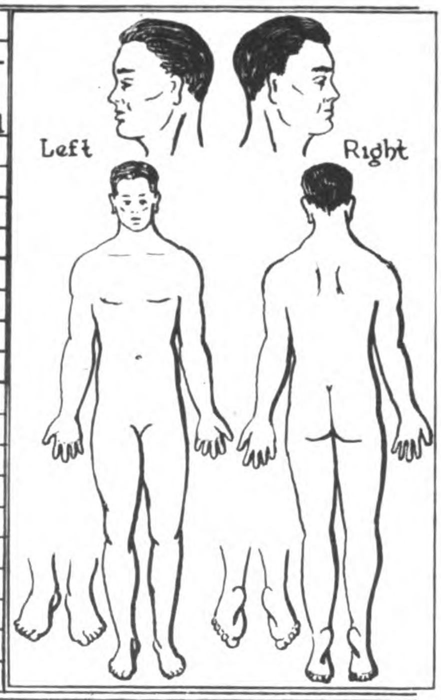
"r" to________ at intervals of________

Remarks________________________

____

Prescribed by:________________
(MC), U.S.N.

RECORD									
K.V.P.		M.A.		Filter		Dist.			Operator Initial
				Ports					
Date	1	2	3	4	5	6	7	8	



When a course of treatment is finished a summary of it should be prepared and forwarded to the medical officer who referred the case. In the case of service personnel this summary should be entered in the health record. This will help prevent people, who in the nature of things move about the whole world, from receiving an excessive amount of X-ray therapy for such persistent and recurrent disorders as fungous infections of the feet, psoriasis and other skin ailments. It will also provide a convenient record in cases that will need follow-up treatment elsewhere.

Usually not more than 700-1000 "r" units (superficial therapy) will be given to a given skin area in a year except in cases of malignancy where, of course, damage to the skin must be risked or accepted as one would a surgical scar. Neither does this limitation apply to small lesions such as warts, calluses or keratoses, or to applications of heavily filtered deep therapy to various regions.

Patients receiving large amounts of radiation should have periodic blood counts, particularly the white count. If the W.B.C. goes below 3000 it is best to withhold radiation, preferably for several months. These heavily irradiated patients are also benefited by receiving liberal amounts of vitamins, particularly the "b" complex. Liberality in the use of carbohydrates and fruit juices is to be recommended.

When patients receive more than 200 "r" over any considerable area at one time there may be some radiation sickness usually evinced by nausea. If cases are in out-patient status it is well not to push treatment too hard or they may have to interrupt it.

In long courses of deep therapy the skin is often the limiting factor. It is well to make close observation remembering the cumulative effect. When very heavily filtered radiation, often from a 400 - 1000 K.V.P. generator, is used it must be remembered that, due to the greater depth dosage, signs of intestinal irritation such as abdominal pains and passage of excessive mucus may develop before the skin shows much effect. These signs of intestinal irritation should be differentiated from ordinary nausea from radiation, and, if really present, should not be neglected. If radiation is persisted in unduly, in the face of such signs and symptoms, serious trouble may result.

When radiation therapy over the pelvic region is contemplated in the case of women the effect on the ovaries must be considered unless the menopause has been passed. Furthermore, no therapeutic radiation over the pelvis or abdomen is permissible during pregnancy. The radiation used in routine radiography for obstetrical purposes is ordinarily inconsequential.

Strong medications should not be applied to the skin when X-ray therapy is being given. These include, iodine, strong preparations of salicylic or benzoic acid such as Whitfield's ointment, strong mercurials, icthyol, etc. Don't forget to caution patients.

Exposure to sunlight or ultra-violet light should also be minimized or in the case of heavy radiation, prohibited.

The sulphonamide drugs do not call for absolute interdiction of X-ray therapy but do call for caution. The radiologist should ascertain how much, if any, of this drug is being given when a case of infection is referred for X-ray treatment.

(b) Safeguards for people stationed near X-ray apparatus:

This, of course, is a matter of intercepting X-radiation. The amount and type of protection called for is indicated in the following recommendations from the Bureau of Standards.

General Recommendations:

"All X-ray rooms (except for dental radiography) or booths shall be lined throughout with sheet lead or equivalent material of assured quality, uniformity and permanency, care being taken that there be complete overlapping of all joints."Protective plasters" and lead rubber wall board are considered to be unsatisfactory for providing protection exceeding 1 mm. lead equivalent."

"The following lead equivalents are recommended as adequate:

X-rays Generated by Peak Voltages not in Excess of -	Minimum Equivalent Thickness of Lead
Kv	mm.
75	1.0
100	1.5
125	2.0
150	2.5
175	3.0
200	4.0
225	5.0
400	15.0 "

Requirements for Diagnostic Purposes up to 130 Kv:

"The equivalent of 1 mm. of aluminum shall be permanently mounted between the tube target and patient in all fluoroscopic tube inclosures and 0.5 mm. of aluminum in all radiographic tube inclosures. Part or all of this may be contained in the glass of the tube walls."

"Radiographic and radioscopic rooms shall be lined throughout with at least 0.5 mm. of sheet lead or equivalent material of assured quality, uniformity and permanency. (Exception - This may be omitted only on outside walls and sides adjacent to unoccupied rooms)."

"To protect the operator and personnel, control apparatus for radiographic work should be in an adjacent room which provides protection equivalent to at least 0.5 mm. of lead or inclosed in a lead-lined booth within the radiographic room."

"Either control room or booth shall be provided with a suitably large lead-glass window of 2.0 mm. lead equivalent."

"Protection from direct and useful radiation may be omitted only on sides adjacent to permanently unoccupied rooms or outside building walls."

"The tube container and treatment table should be so arranged that the useful beam points away from the technician's booth, offices, etc."

(c) Protection of X-ray workers:

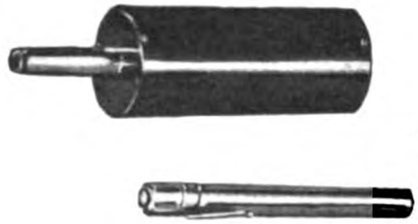
Incidental to the above many points have already been covered. What applies to the patient in regard to direct radiation naturally applies with still more force to the persons who are working with X-ray every day. It remains to consider the more insidious effects.

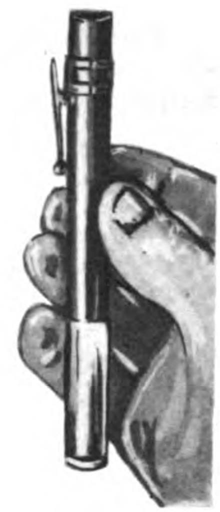
As noted a while back, X-ray should be regarded as an irritant. Its action is profound and selective. It affects some tissues much more than others and elaborate lists have been drawn up to show the order of sensitivity. For general purposes, however, it is only necessary to bear in mind one fundamental feature as regards selective action and that is that X-ray has the greatest effect on the cells that are multiplying, i.e., undergoing mitosis. From this one can readily understand that the X-ray will have a specially pronounced effect on the blood forming cells, gonadal cells, germinal layers of the skin and the hair follicles.

From a practical standpoint workers in X-ray who have been neglectful of safety precautions are most apt to show skin changes, low white blood counts (and in time red blood count) and sterility - usually temporary.

Safety measures involve keeping out of all direct radiation and minimizing exposure to secondary radiation. This is best accomplished by having the controls behind lead protection in a control booth or behind a permanently installed lead screen. The modern types of tubes (ray-proof) are safer than the old types which were mounted in open lead glass bowls, but considerable secondary radiation will result from all types of tubes. The amount of radiation that will produce harmful effects from long continued work in X-ray appears to be in excess of 0.2 - 0.288 r per sq. cm. per day. Since it is difficult to do more than guess at how much radiation one absorbs in the course of the day's work it is a good plan to make an occasional radiographic test. This is very simply carried out by placing dental films in several pockets and/or in various places about rooms one may be concerned about. Paper clips or identifying lead numbers should be fastened on them. Naturally the lead-lined surface should be next the body. After two weeks, the films are developed. If the films show a distinct image of the clip or metal numbers, surrounded by a fairly dense field, better protection is advisable. A recently developed highly sensitive measuring device is available to measure small amounts of stray or secondary radiation. This is the "Minometer".

In addition to the above, personnel engaged in X-ray work that involves exposure should have blood counts every quarter and if exposure is particularly heavy, every month.





MINOMETER

A double scale is provided, 0 - 0.1 and 0 - 0.01 "r" and to be used with the 0.1 and 0.01 "thimbles" respectively.

In use, the instrument is plugged into a 110 A.C. volt line. A built-in rectifier system changes the A.C. to D.C. (See Appendix) and is used to charge the electroscope to zero mark.

The "thimble" is subjected to X-ray which ionizes the contained air to an extent dependent upon exposure. When the "thimble" is inserted into the chamber, the electroscope will discharge up the scale to show the fractional part of "r" unit for the time used in X-ray exposure. This "r" output is usually computed on the basis of so many "r" per minute. This thimble can be left any appropriate time in a given location or may be worn by a technician or other persons exposed to X-radiation.

Ventilation should not be neglected. It is probable that X-ray exposure is often blamed for symptoms that are due to lack of ventilation with attendant presence of ozone, nitric oxide fumes, carbondioxide and excessive humidity. If a continuous ventilation system by an adequate exhaust fan or air-conditioning apparatus is absent then such rooms as the fluoroscopic room and small control rooms should be aired out between cases. An electric fan is always a help in warm weather and where natural ventilation is poor, indispensable.

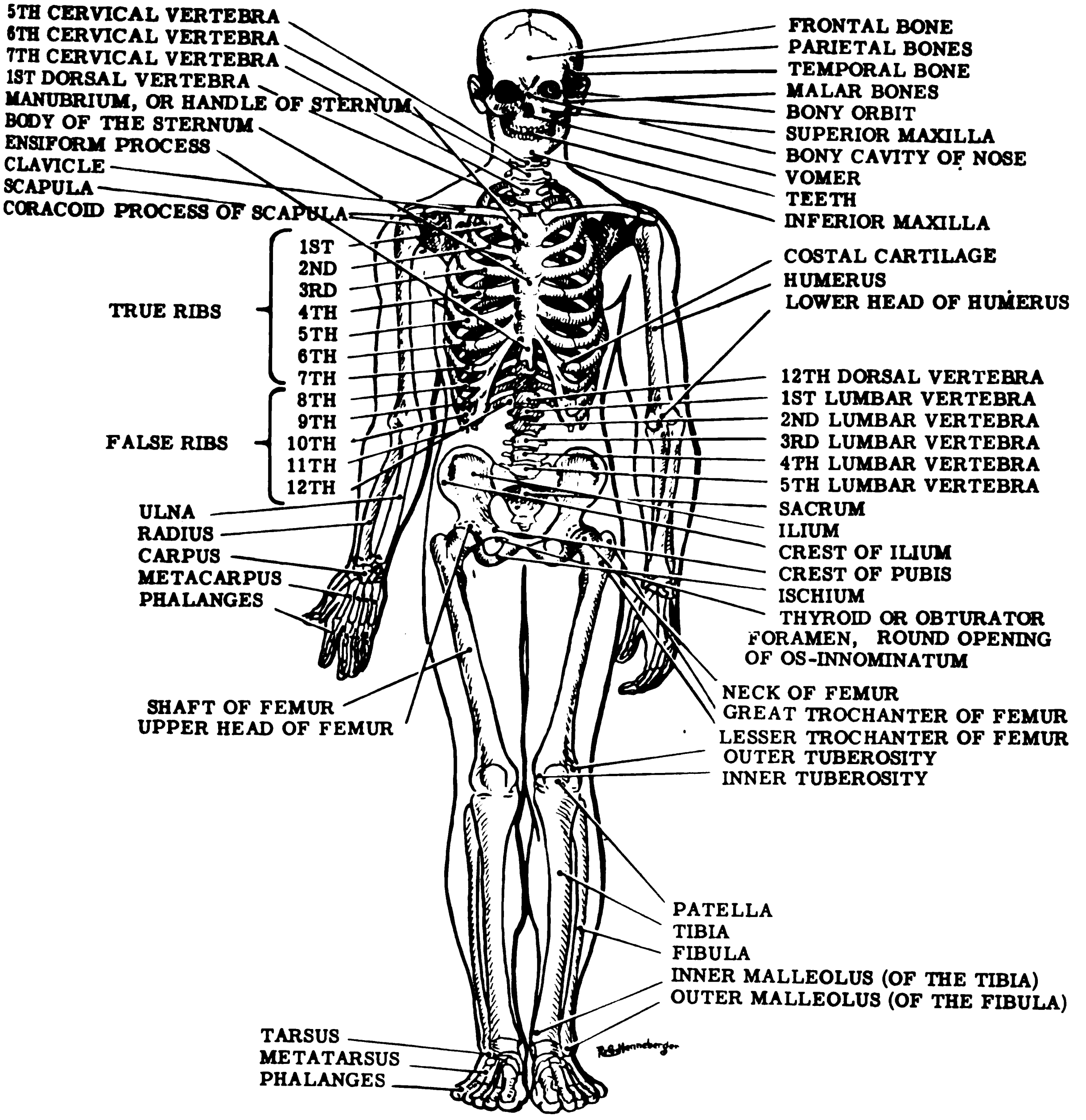
General rules of hygiene are particularly indicated for X-ray workers. Aside from the effects of radiation, the occupation is confining. Hence recreation in the open air is desirable, and, if possible, vacations should be arranged so that a full month can be taken at one time, rather than having the time split up in fractions. The full month away from all radiation is more beneficial. In many departments

rotation of work will make it possible for each worker to spend a month or more in clerical or other work that involves no exposure to X-ray and under such conditions leave periods become no more important than for other workers.

Fluorography calls for special care, because it is usually done on a large scale. Technicians should have a W.B.C. monthly and take a rest period from radiation if count drops below 5,000.

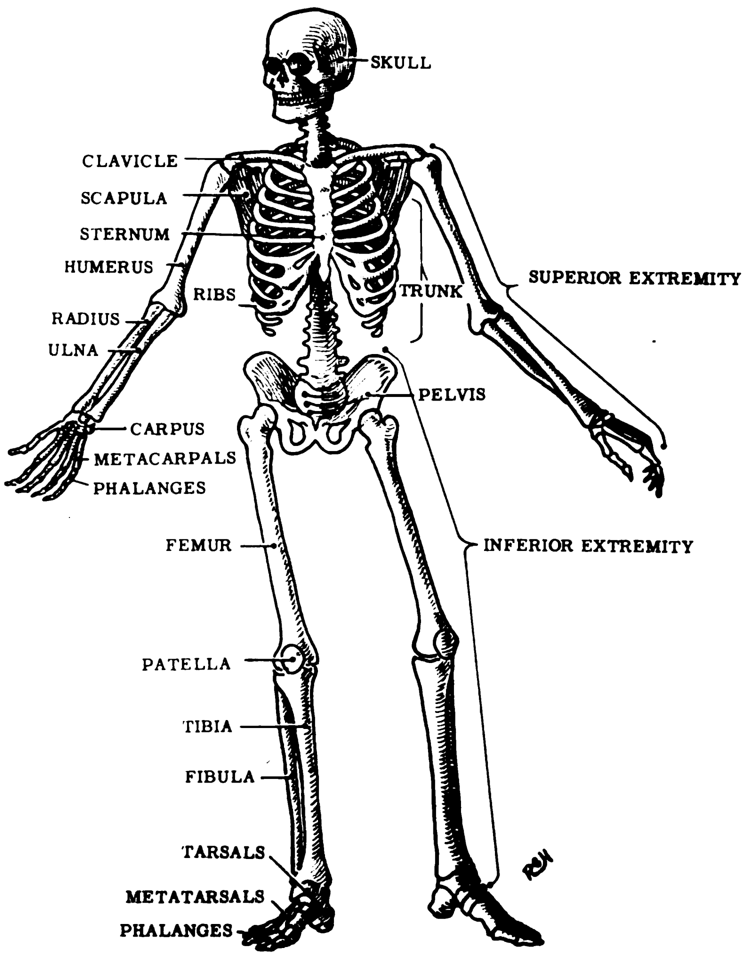
QUESTIONS:

1. List main fluoroscopic precautions.
2. Upon what does the amount of tube shift depend, in making stereoscopic films?
3. Chest stereos require what special precautions?
4. What effect does the Bucky have on stereoscopic procedure?
5. What is a photofluorograph?
6. What current supply is required by the condenser discharge unit for photofluorography?
7. What type lens and camera is used?
8. Outline processing of 35 millimeter film.
9. (a) What is meant by sectional radiography?
   (b) State several other names for this procedure.
10. What is the Kymograph?
11. Describe a simple method of foreign body localization by fluoroscopic means.
12. Describe a triangulation method of localization.
13. Name two methods of localizing foreign bodies in the eye; describe contact lens principle.
14. List main electrical safeguards.
15. State maximum permissible MAS at 14 inch target skin distance, 85 KV., millimeter aluminum filter for:
    (a) head
    (b) other parts
16. What is the first and chief effect of X-ray in large amounts on the blood?
17. Define "r" unit. What instrument is used to measure dosage?
18. What rules should be followed to avoid injury to patients undergoing X-ray therapy.
19. Define "half value layer" as used in therapy; effective wave length.
20. What procedure is to be followed before using a deep therapy machine at full capacity?
21. Describe operation principle of a Victoreen "r" meter.
22. List rules as to care of victoreen meter.
23. (a) Name and describe the three rays derived from Radium.
    (b) Differentiate each from X-ray.
24. What is Radon?
25. In composite filters what metal is placed nearest the patient?

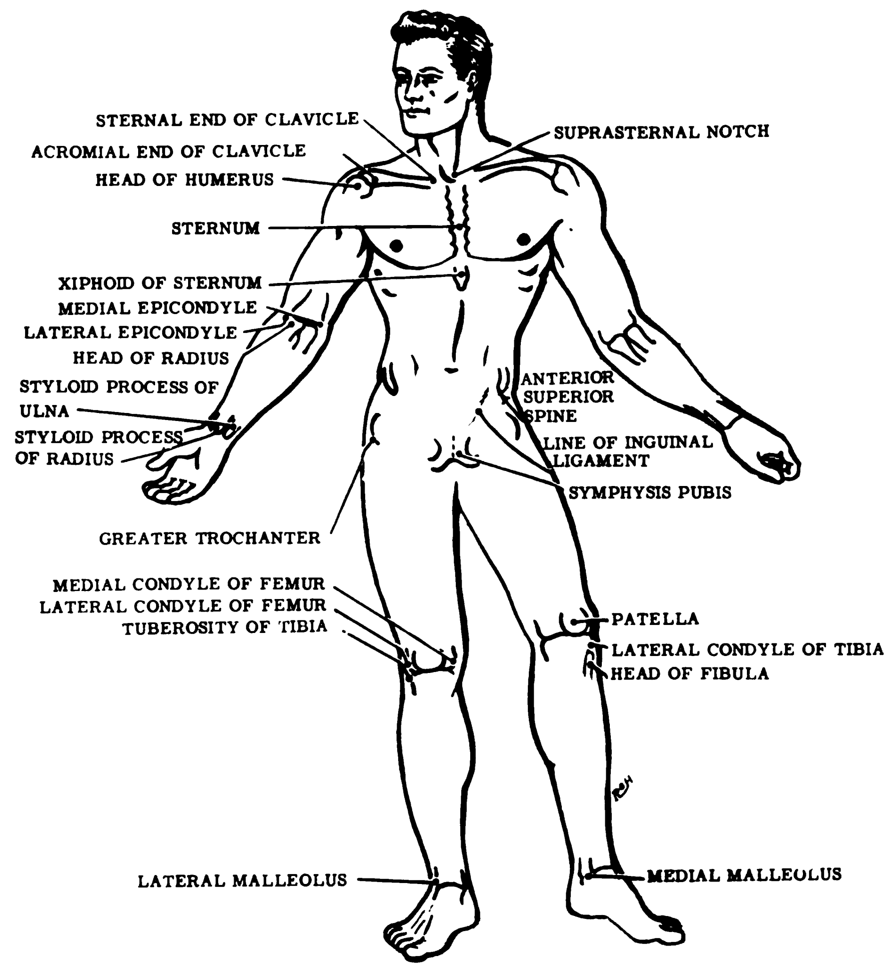


ANTERIOR VIEW

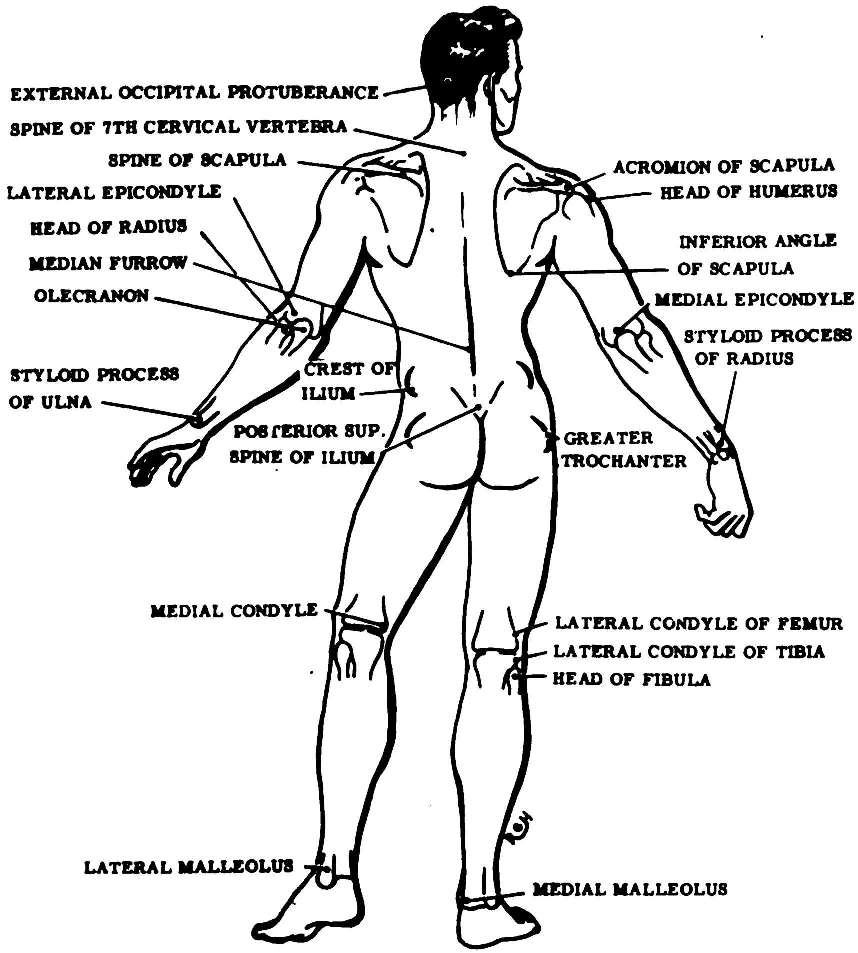
THE RADIOGRAPHIC SKELETON



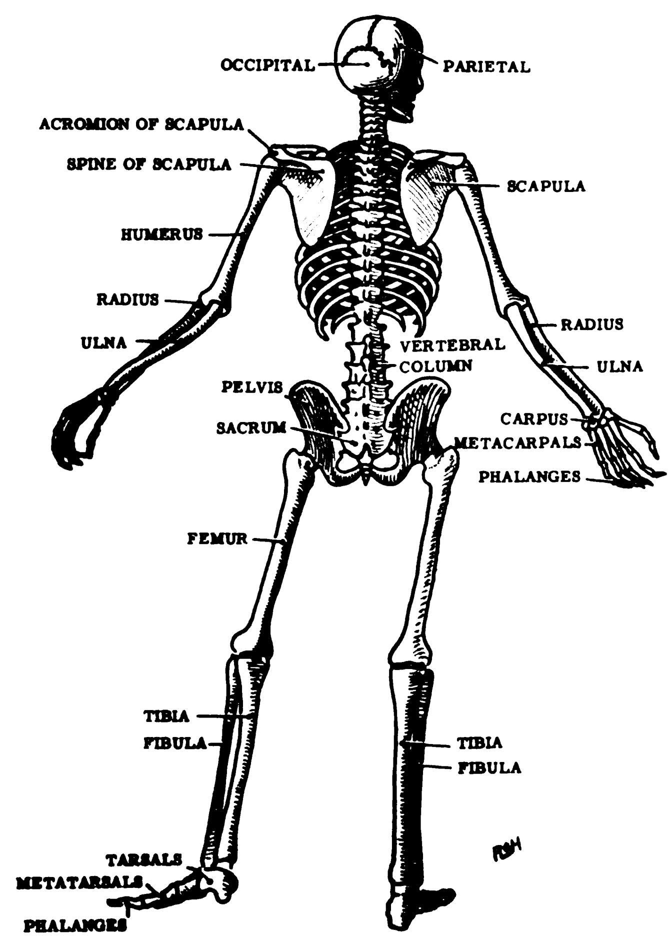
SKELETON, ANTERIOR VIEW WITH LABELED LEADERS.



ANTERIOR SURFACE VIEW SHOWING LANDMARKS AND PROPORTIONS.



POSTERIOR SURFACE VIEW SHOWING LANDMARKS AND PROPORTIONS.



SKELETON, POSTERIOR VIEW WITH LABELED LEADERS.

APPENDIX

Service Data:

When X-ray apparatus fails to function some knowledge of common causes of such failures is of great value. One need not be an expert service man to remedy many troubles. Further,it is important that one be able to ascertain,when in remote stations, what part, if any, must be replaced. A large number of failures are traceable to broken circuits and blown fuses that are neither difficult to diagnose nor correct.

Certain basic things must be born in mind.

1. X-ray apparatus is dangerous to tinker with carelessly but entirely safe if proper safeguards are not neglected.

2. "Innocent" bystanders are potential dynamite unless you tie their hands behind their backs.

3. When line circuits are involved call in the electrician.

4. Know precisely what you are doing and why. To this end study the blue prints of the apparatus.

5. Before you dig into any X-ray machine, disconnect the current supply at the wall switch or panel board. Further, do not forget that there may be an auxiliary supply for some of the control circuits. This should also be disconnected. If you are not certain it is a simple matter to test by applying one lead of a voltmeter or test lamp to a ground stud and the other to various other studs.

6. Mark each wire that you disconnect. Otherwise you will have some unhappy moments when the time comes to reconnect the wires.

7. Certain transformer units have condensers which will retain a charge for some time after the machine has been shut off. "Ground" out such charges before attempting work on these units.

8. Remember that damp floors,particularly in basements, greatly enhance the danger of severe shocks. Likewise damp hands or wet feet enhance the danger.

9. Remember also that the ordinary 110 volt house current can be just as fatal as the 100,000 volt high tension.

10. In general, "Never take a Chance".

Test Appliances:

1. The simplest appliance in frequent use is the test lamp. Since many X-ray machines make use of 220 A.C. current the bulb should be of that capacity. However, if in testing, one lead is always placed on the ground stud, a 110 volt lamp may be

used. None the less the former is much preferable. The leads to the test lamp should be well insulated except, of course, for the tips.

2. Voltmeters: These come in various ranges up to 3000 volts. For X-ray work a double scale voltmeter with a range up to 25 or 30 on the low scale and 250 or 300 on the high, is desirable. When voltage is unknown always make the first reading with the higher scale or you will soon be in the market for a new instrument.

3. Continuity meters or circuit testers: These are used to test for open or broken circuits, short circuits and high resistance contacts.

This device consists of a current supply (usually a dry cell) and an indicating device such as a buzzer or flashlight bulb in simple types; in more elaborate types a meter in combination with variable resistances is employed. It has its own current supply and must never be used on an energized circuit. Forgetfulness here will mean that the instrument or some important part of it will shortly make the acquaintance of the junk heap.

The better types as purchased employ an Ohmmeter. One can improvise one by combining a resistance box with a D. C. milliameter and dry cell.

Flash light circuit tester:

To make a simple type, a tubular flashlight can be utilized as follows:

1. Unscrew bottom and perforate it in the middle. A nail or ice pick will be convenient for this purpose.

2. Cut a piece of cardboard to fit the bottom, make a small pin hole perforation in its center sufficient for an ordinary bare wire to pass through.

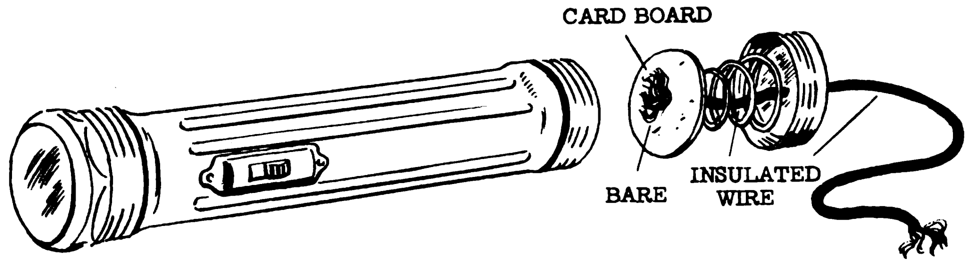
3. Bare the ends of an insulated wire for 1/2 inch and pull one end through the perforation in the flashlight base passing it through the spring.

4. Pass the bare end of the wire through the cardboard until the insulation impinges on it and then bend the bare wire over.

5. Screw the base in place.

The result of this adaptation is, of course, to break the usual contact between the battery case and the base of the dry cell and thus its bulb cannot light unless contact is established between the end of the wire lead and the battery case. The application to circuit testing is obvious. The battery case forms one terminal and the wire end the other. Naturally it should be tested before use.

In use a broken circuit is indicated by failure of the bulb to light or the buzzer to sound, or again for the ammeter to register, if one is employed. A high resistance contact results in a dull glow, a feeble buzz or low readings.



FLASHLIGHT CONTINUITY METER.

The sphere gap is used to measure high tension voltages. With the older types of apparatus and where aerial systems are present its use is simple. Where the unit is completely shock proof special adapters are required. The sphere gap is ordinarily calibrated in K.V.P. based on standard atmospheric conditions. If it is simply calibrated for distance between the spheres conversion charts will be needed. These differ with the diameter of the balls and consequently the diameter must be known. Sphere gap distances are also greatly different from those of point gap. 12.5 cm. balls are frequently used.

TABLE

K.V.P.	Sph. Gap (12.5 cm. balls)	Pt. Gap (Dull)
30	1 cms.	
35	1.2 "	
40	1.3 "	
45	1.5 "	
50	1.7 "	7.6 cms.
55	1.9 "	8.8 "
60	2.1 "	9.3 "
70	2.5 "	11.4 "
80	2.9 "	12.8 "
90	3.3 "	14.6 "
100	3.8 "	16.5 "
120	4.6 "	20.3 "
140	5.6 "	24.8 "
160	6.6 "	29.2 "
180	7.7 "	33.1 "
200	9.0 "	37.4 "

The balls of the sphere gap are mounted on rods arranged so that the spheres can be approximated by pulling a string while the high tension current is on. When they reach the proper point the current jumps or arcs over. The distance between the spheres indicates the voltage. Naturally the higher the voltage the larger the

distance the current will jump.

When the current jumps there tends to be a sudden surge. This is diminished by the presence of resistors between the spheres and the terminals.

In operating the appliance bear in mind the following:

1. In using the sphere gap be sure that the scale you are using is for the size spheres on the gap and the altitude at which you are working.

2. See that the pointer reads O when the gaps are closed. Be sure there are resistances in series with each end of the sphere to prevent too great an arc. (This will prevent pitting of the spheres).

3. Start with the gap beyond the arcing point and pull it in smoothly, taking no more than three seconds to reach the arcing point.

4. Do not exceed capacity of X-ray tube.

5. Bring the spheres together completely after making a reading.

6. Keep spheres polished and use care to prevent pitting or denting.

7. Do not use gap to check the voltage of a self rectified machine, as readings will be incorrect.

8. Any ground circuit milliammeter (such as are on X-ray control panels) should preferably be shorted out before using a sphere gap (to prevent damage by surges).

9. If there are meters in the aerial system connect the spheres in front of them, i.e., between the H.T. transformer and the meters.

10. With high capacity current it will be best to use the timer to get short exposures from time to time as the spheres are approximated.

11. A point spark gap may be improvised from stiff wire attached to the aerial. Short exposures of 1/4 second or less should be used to minimize surges, since resistance will be lacking. The point gap scale must be used of course.

Trouble Hunting:

When an X-ray machine fails to function there are, of course, a number of circuits to consider. However, before undertaking elaborate investigations inspect the controls and all the ordinary connections such as Bucky plugs, etc. Much time has been lost looking for remote trouble when some simple thing has been overlooked such as pushing in the circuit breaker, or turning the autotransformer controls to proper contact, etc. Also inspect fuses closely. The main circuits to be considered are:

1. Main line or supply circuit.

2. X-ray tube filament circuit.

3. Valve tube filament (only, of course, when valve tubes are used).

4. High tension circuit.

5. Control and auxiliary circuits.

Main Line Circuit: This comes from the pole or vault transformer and proceeds through the feed wires to the wall or panel switch (usually fused) through the main switch of the X-ray control and the main fuses of the X-ray to the autotransformer.

The supply circuit is simple but extremely important. A poor supply line will limit the results obtained from a relatively high powered machine to that of a much smaller unit.

Before the installation of a machine the power requirements should be determined, and the proper supply provided to operate it. It is advisable to get the necessary information from the manufacturers who will be glad to be of assistance. Remember that people unfamiliar with X-ray requirements tend to under-estimate the capacity of transformer and wires needed.

The following troubles may occur in this circuit:

1. Poor contacts of main switch accompanied by carbonization or burning of the contact points and freezing of the switch.

2. Blown fuses which call for replacement and search for a short circuit farther along the line if they continue to blow.

3. Short circuited autotransformers. These are indicated by abnormal heating or burning of insulation, dependent upon the severity of the short.

4. Open circuit or broken contact indicated by no voltage reading in the circuit.

Filament Circuit of X-ray Tube: This proceeds from the supply, (either line or autotransformer), through a control device, such as a choke coil, to a step down transformer in the X-ray control unit and lights the filament. It passes through a filament ammeter when control of the M.A. is manually adjusted; or through automatic regulating devices in the "selector" or monitor types of modern machines.

Failure of the filament circuit is indicated by:

1. Incorrect reading of milliameter or no reading.

2. Incorrect reading of filament ammeter or no reading.

These will be associated with a dull glow of filament or no glow at all.

A short circuit in the filament leads is indicated by high ammeter reading but no M.A. in the high tension circuit.

A broken circuit is indicated by no reading on either meter.

In searching for the cause:

1. Test X-ray tube filaments. Filament failure is not uncommon with modern high capacity technique and this should be one of the first things to look for.

Simple inspection may indicate that one or both filaments fail to light, but it will be well to verify the status of the filaments by applying a continuity meter, as the tube may fail to light because of poor connection. Remember that in case of most tubes there is a double focal spot and accordingly two filaments to be tested. There will be three leads in this type tube, one common to both filaments and an additional one for each.

2. Inspect and test fuses for the circuit.

3. Inspect cathode connections of the tubes. In old non-shock-proof tubes poor contacts here are not infrequent. Tension from spring reels often pulls them loose. Short circuits often occur here also. Shock proof cables are less frequently at fault. However, the split pin connectors used here may need to be slightly widened. If white vaseline has been used be sure to replace it. When the cables are reconnected make sure the contact pins are in their sockets before the connection is tightened.

4. If no fault is present in the connections test the whole wire by using the continuity meter after disconnecting the filament wires at both ends.

Valve Filament Circuit: This also comes from a step down transformer. Failure will be indicated by one or more valve tubes failing to light, and aberrant behavior of the filament ammeter. Its fuses, connection and leads are tested in order.

High Tension Circuit: This circuit supplies the high voltage necessary to drive the electrons from the filament to the target of the X-ray tube. The primary of the high tension circuit is supplied in the case of the fixed K.V.P. machine directly from the line. In larger machines supply is through the major and minor adjustments on the autotransformer and perhaps a rheostat in series with one side of the primary.

The secondary of the majority of high tension transformers is usually center grounded.

The high tension primary circuit consists of:

1. Major and minor autotransformer controls with voltmeter.

2. Coil for circuit breaker or over-load relay.

3. Contacts of magnetic switch.

4. Primary of high tension transformer.

The major adjustor usually varies the output of the high tension transformer output by 10 K.V.P. The minor adjustor usually varies the high tension transformer output by 1 or 2 K.V.P.

The prereading voltmeter indicates voltage from the autotransformer and must be calibrated for K.V.P. output of the high tension transformer if connected directly across the adjusted high tension primary voltage.

If the prereading voltmeter has its voltage supplied by a separate winding on the autotransformer through a potentiometer and other variable resistances to the voltmeter, these resistances can be automatically varied to compensate for the difference in drop accompanying changes in milliamperages. The voltmeter may then directly indicate the expected high tension K.V.P.

The circuit breaker is formed by a solenoid coil which causes sufficient pull on an iron core to separate the contacts in the holding coil of the magnetic switch circuit when too much current flows through it.

<u>High Tension Secondary Circuit:</u> The high tension secondary consists of the secondary winding of the high tension transformer, the milliammeter circuit, the rectifying circuit, the high tension supply line, and the X-ray tube.

When the high tension fails note if there is failure of X-ray or valve tube circuits. Investigate the magnetic switch and also the relay device for any Rotating Anode Tube. (If rotor fails to start no high tension will be forthcoming as result of safety relays). If the magnetic switch closes, trouble is in the high tension leads. If it fails to close, there is trouble in the control circuits or the switch itself - usually the former.

The Bucky contacts may be dirty and prevent contact or its connector plugs may be disconnected. Contacts in the push button may be broken. Foot switch leads may be broken; they are subject to considerable stress. The Bucky selector switch on the control panel may not be correctly adjusted.

When the high tension side is at fault trouble may be in the leads. A short circuit will cause the circuit breaker to "kick" out or an excessive drop in the voltage. An open circuit will simply be "dead".

The autotransformer circuit can be tested with a voltmeter back from the supply in front of the magnetic switch, to the various studs. If there is no trouble there, the voltmeter can be applied to the load side of the switch after the switch is closed. If no current is then obtained the magnetic switch is at fault.

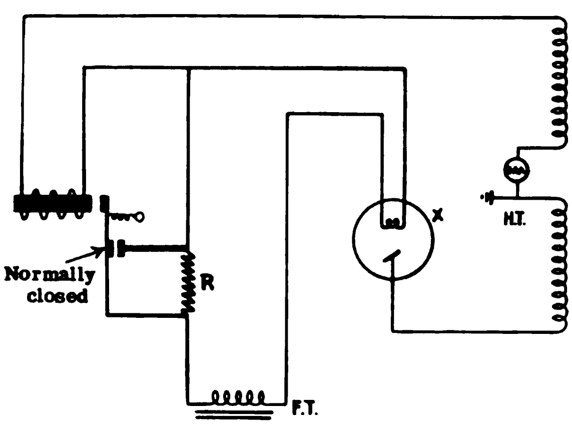
The high tension shock proof cables can be tested by applying current to them while they are suspended freely in air, disconnected from the tube. If no breakdown, i.e., shorting occurs, they are not at fault. If it does, remove the cables one at a

time to determine which may be the faulty one. If shorting occurs with both removed, the transformer is at fault. The transformer windings can be tested with the continuity meter; naturally the current must be cut off first.

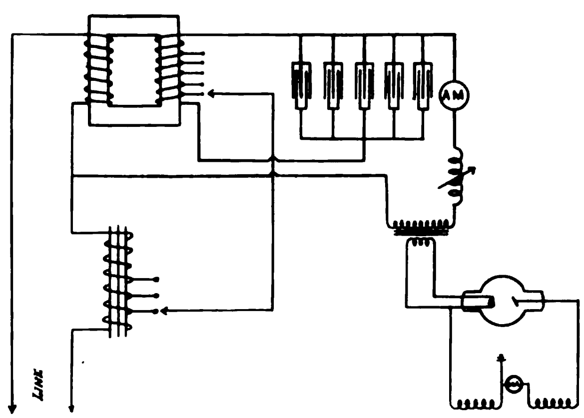
When the tube is at fault no breakdown occurs when the cables are detached from it and tested as above. Erratic readings of the M.A. in faulty tubes usually indicates gassiness.

Stabilizers: These are used to minimize fluctuation of current through the X-ray tube.

An old type is the Kearsley stabilizer which worked well on moderate or long exposures but is too slow in reaction for the extremely short exposures. The following diagram indicates the fundamental of the circuit. Operation depends on an added resistance being thrown in the filament circuit when the current exceeds a given point which is predetermined by a calibrated adjusted knob.



KEARSLEY STABILIZER



ELECTROMAGNETIC STABILIZER

A more modern type which functions very well is the electromagnetic type which employs condensers and closed core transformer "bucked" by an open core or "choke" type transformer as per diagram. The closed core transformer carries the main burden and is run at saturation with the condenser shunted in. The choke coil is run well below saturation. Current surges produce impedance in the choke type transformer. This action plus condenser effects produces efficient stabilization. The taps noted in the diagram are for adjustment to local current conditions and type of machine.

Control Circuits: As mentioned already, trouble is frequently encountered with foot switches, push buttons, relay devices, Bucky contacts, etc. Inspection and testing with the continuity meter will solve most problems here. Timers are complicated affairs and when they are out of order replacement or repair by special service men will be needed. Remember that a Bucky timer can be used for timing exposure in emergency.

Tiding over emergencies:

1. If a valve burns out, the machine can often be operated either as a half wave rectified unit (reducing M.A. load by 1/2); or in the case of a single valve, half wave rectified unit, it may be operated at reduced capacity as a self rectified machine. It will be necessary to wire across the valve in the case of single valve units.

2. If the motor of a mechanically rectified unit fails, disconnect the supply to the motor and wire the disc so the collector segments coincide. Then operate it as a self rectified unit, naturally at reduced capacity (not over 20 M.A. and with lower K.V.P. settings).

3. If cooling devices such as blowers or water circulation, etc., fail simply allow more time for cooling and observe closely.

4. When regular timers fail, a Bucky, if available, can serve as noted above.

Pointers on Fuses:

1. Shaking a fuse is no satisfactory test.

2. Puzzling behavior may be due to an arcing contact. Therefore, when a fuse is in question do not fail to open it for close inspection; or replace it with one known to be perfect.

3. If you test it with a continuity meter, it should be removed from its clips.

4. When using a test lamp be sure to apply it correctly.

5. Be sure to use fuses of correct capacity.

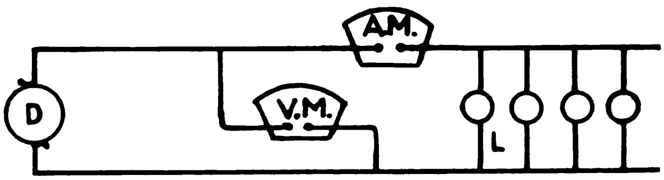
6. Never short a fuse out by a wire or (in the case of screw plug fuses) a coin.

7. Do not mistake a fuse for a small resistor.

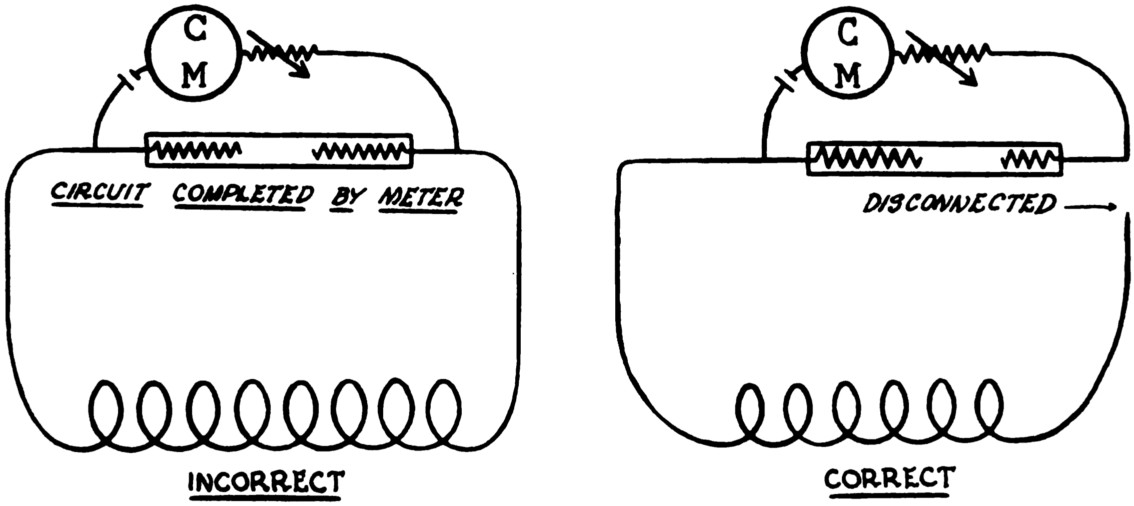
Pointers on Meters:

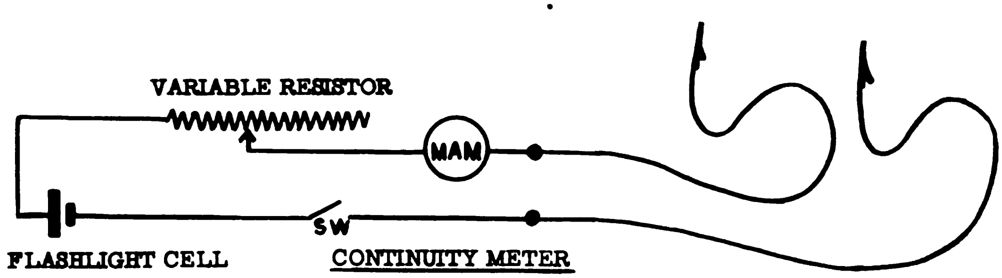
1. The voltmeter must be connected across the lines.

2. The ammeter must be connected in series.

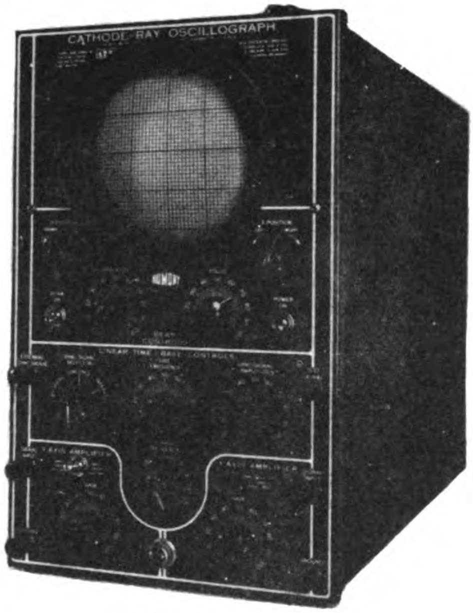


3. **The circuit tester or continuity meter requires that the current supply be cut off and that the wire to be tested be disconnected. Otherwise a broken circuit will fail of detection.**



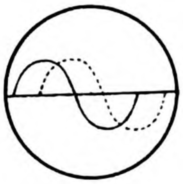


VARIABLE RESISTOR SHOULD BE SET TO OBTAIN FULLSCALE DEFLECTION OF THE MILLIAMETER WHEN THE TEST TERMINALS ARE SHORTED. THE RESISTOR MAY BE OF EITHER BOX OR SLIDING TYPE. THIS TYPE CONTINUITY METER IS MUCH SUPERIOR TO THE "ROUGH AND READY" FLASHLIGHT TESTER.

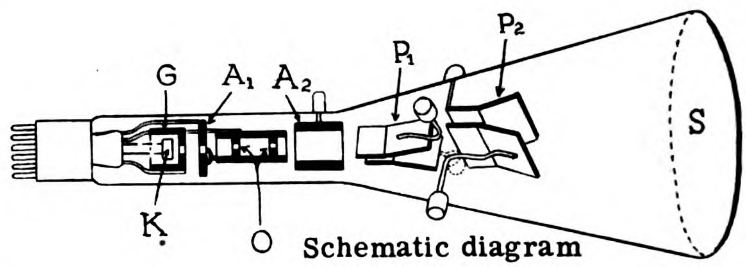


OSCILLOSCOPE

MULTIMETER

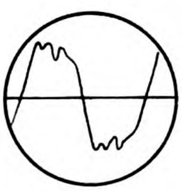


A

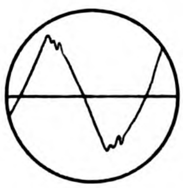


Schematic diagram of cathode ray tube.

K = Cathode - G = Control grid
A_1, A_2 = Anodes - S = Screen
P_1, P_2 = Deflecting plates



B



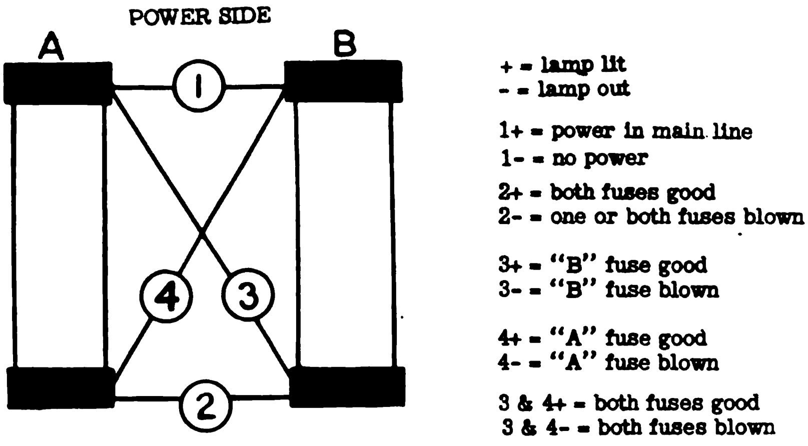
C

A - oscillograph of wave-form showing current lagging voltage, as in choke coil.
B - wave-form showing good mean effective voltage.
C - waveform showing poor mean effective voltage.

This instrument employs a focused beam of cathode rays to visualize variations in potential on a special screen, reproducing their wave forms.

This is accomplished by passing the cathode ray between "deflecting" plates or magnetic fields to which the potentials or currents under test are applied, depending on the type of instrument.

The electrostatic type uses deflecting plates; the electromagnetic type, coils.



APPLICATION OF TEST LAMP TO PAIR OF FUSES

QUESTIONS:

1. List precautions relative to repair work on X-ray apparatus.

2. Name principal test appliances.

3. Describe how to make a continuity meter or circuit tester from a tubular flashlight.

4. Describe how to use a sphere gap.

5. List the X-ray circuits.

6. What would indicate:
   (a) failure of main line circuit.
   (b) blown fuse in the supply circuit of X-ray.
   (c) failure of X-ray filament circuit.
   (d) failure of valve tube filament circuit.
   (e) dirty or broken bucky contacts.
   (f) failure of shock proof cables.
   (g) transformer breakdown.
   (h) gassy X-ray tube.
   (i) failure of relay for rotating anode.

7. Describe use of test lamp.

8. Describe testing of a fuse with a continuity meter.

9. Describe proper method of connecting:
   (a) ammeter.
   (b) voltmeter.
   (c) continuity meter.

NOTES ON INSTALLATION AND SERVICE REQUIREMENTS.

Basic plans are now available in the Bureau of Medicine and Surgery for X-ray installations of various types suitable to the particular activity. These provide very adequate facilities. It is, of course, necessary to adapt basic plans to the space available and take into account various considerations. It is not within the province of this manual to go into details of planning, but it is worth while to call attention to some things which may require local consideration. Of these, power requirements are among the most important.

Power Supply:

The tendency is to underestimate power needs and it is necessary to remember that a voltage drop, neglible with most electrical equipment, can make the difference between a good radiograph and one totally inadequate because of the disproportionate effect of Kv. drop on radiographic density.

This matter naturally comes into play chiefly in high capacity work, and hence most chest work. Since consistent interpretation of chest films calls for the highest possible degree of uniformity in technical characteristics, the matter becomes one of really marked importance.

The heavy load produced by high capacity X-ray apparatus occupies only a fraction of a second in time and this means that line fluctuation must be avoided. Voltage variations must be less than 2% with no X-ray load. Therefore, it is not permissible to have heavy apparatus, such as elevators, powered off the same transformer.

The following table indicates the supply requirements in the absence of any additional load in excess of 2 KW. These figures should be considered as standard requirements and it will probably be an advantage to secure larger transformers when possible, especially since the tendency is to add more apparatus rather than the reverse with resultant increase in transformer load.

Type of X-ray	Supply Transformer Rating Kv.A.	Supply wire (A.W.G.) at Lead-in Distance	
		40 Meters (131.2 Ft.)	80 Meters (262.4 Ft.)
100 Kv. 100 MA. Single Phase Full wave	7.5	6	4
100 Kv. 200 MA. Single Phase Full wave (or) 100 Kv. 100 MA. Self rectified	15.0	2	0
100 Kv. 500 MA. Single Phase Full wave	25.0	0	0000
100 Kv. 750 MA. Three Phase Full wave	20.0 (3-Phase)	2	1

Complete table follows.

Wire Table, Standard Annealed Copper at a Temperature of 25° Centigrade (77° Fahrenheit)

American Wire Gage (Brown & Sharpe)

Gage No.	Diam. in Mils d	Area	Weight		Length		Resistance	
		Cir. Mils d^2	Lbs. per 1000 ft.	Lbs. per ohm	Feet per lb.	Feet per ohm	Ohms per 1000 ft.	Ohms per lb.
0000	460.0	211600.	040.5	13810.	1.561	20010.	0.04998	0.00007805
000	409.6	167800.	507.9	8057.	1.968	15870.	.06303	.0001217
00	364.8	133100.	402.8	5067.	2.482	1_380.	.07947	.0001935
0	324.9	105500.	319.5	3187.	3.130	9979.	.1002	.0003138
1	289.3	83690.	253.3	2004.	3.947	7913.	.1264	.0004990
2	257.6	66370.	200.9	1260.	4.977	6276.	.1594	.0007934
3	229.4	52640.	159.3	792.7	6.276	4977.	.2009	.001262
4	204.3	41740.	126.4	498.6	7.914	3947.	.2534	.002006
5	181.9	33100.	100.2	313.5	9.980	3130.	.3195	.003189
6	162.0	26250.	79.46	197.2	12.58	2482.	.4029	.005071
7	144.3	20820.	63.02	124.0	15.87	1968.	.5080	.008064
8	128.5	16510.	49.98	77.99	20.01	1561.	.6406	.01282
9	114.4	13090.	39.63	49.05	25.23	1238.	.8078	.02039
10	101.9	10380.	31.43	30.85	31.82	981.8	1.019	.03242
11	90.74	8234.	24.02	19.40	40.12	778.5	1.284	.05155
12	80.81	6530.	19.77	12.20	50.59	617.4	1.620	.08196
13	71.96	5178.	15.68	7.673	63.80	489.6	2.042	.1303
14	64.08	4107.	12.43	4.826	80.44	388.3	2.576	.2072
15	57.07	3257.	9.858	3.035	101.4	307.9	3.248	.3295
16	50.82	2583.	7.818	1.909	127.9	244.2	4.095	.5230
17	45.26	2048.	6.200	1.200	161.3	193.7	5.161	.8330
18	40.30	1624.	4.917	0.7549	203.4	153.6	6.512	1.325
19	35.89	1288.	3.899	.4748	256.5	121.8	8.210	2.106
20	31.96	1022.	3.092	.2986	323.4	96.59	10.35	3.349
21	28.46	810.1	2.452	.1878	407.8	76.60	13.06	5.325
22	25.35	642.4	1.945	.1181	514.2	60.74	16.46	8.467
23	22.57	509.5	1.542	.07427	648.4	48.17	20.76	13.46
24	20.10	404.0	1.223	.04671	817.7	38.20	26.18	21.41
25	17.90	320.4	0.9699	.02938	1031.	30.30	33.01	34.04
26	15.94	254.1	.7692	.01847	1300.	24.02	41.62	54.13
27	14.20	201.5	.6100	.01162	1639.	19.05	52.48	86.07
28	12.64	159.8	.4837	.007307	2067.	15.11	66.18	136.8
29	11.26	126.7	.3630	.004595	2607.	11,98	83.46	217.6
30	10.03	100.5	.3042	.002800	3287.	9.503	105.2	346.0
31	8.928	79.70	.2413	.001818	4145.	7.536	132.7	550.2
32	7.950	63.21	.1913	.001143	5227.	5.976	167.3	874.8
33	7.080	50.13	.1517	.0007189	6591.	4.739	211.0	1301.
34	6.305	39.75	.1203	.0004521	8310.	3.759	266.1	2212.
35	5.615	31.52	.09542	.0002843	10480.	2.981	335.5	3517.
36	5.000	25.00	.07568	.0001788	13210.	2.364	423.0	5592.
37	4.453	19.83	.06001	.0001125	16660.	1.874	533.5	8892.
38	3.965	15.72	.04759	.00007074	21010.	1.487	672.7	14140.
39	3.531	12.47	.03774	.00004448	26500.	1.179	848.2	22480.
40	3.145	9.888	.02993	.00002798	33410.	0.9349	1070.	35740.

When a number of units are employed in a department, increased power is needed. A large department with several 500 M.A. Machines, fluoroscopic, cystoscopic and therapy installations will probably require a 100 Kv.A. transformer with #00 to 0000 lead-in wire. Smaller installations will usually require anywhere from a 15 to 50 Kv.A. transformer, depending on the number and capacity of machines in use.

In activities where a 3-phase unit is in use along with several single phase units, it is advisable to provide a separate transformer for the 3-phase unit. Otherwise the 3-phase current as supplied to the X-ray machine will often be out of balance due to the load placed on a single phase.

MINIMUM REQUIREMENTS WITH 100 FT. LEAD-IN
(For 200 ft. - Double size of wire)

Classification	Output MA.	KV.	Line V	Recommended Trans. (KVA)	Size wire (B&S) Trans. to Switch	Size wire (B&S) Line sw. to Control	Ground Wire (B&S)	Fuse Size Amps.	Line Switch Amps.
Self-Rectified: 10 MA	10	85	115 230	1.5 1.5	8 12	- -	8 8	15 10	Base Receptacle
15 MA	15	75	115 230	3 3	6 10	- -	8 8	30 15	Heavy Duty Receptacle
30 MA	30	85	115 230	5 5	6 10	- -	8 8	40 25	60 30
60 MA	60	85	230	10	6	-	8	50	60
100 MA	100	85	230	15	4	6	8	70	100
Half Wave: (1 Valve) 100 MA	100	100	230	15	2	4	8	80	100
Half Wave: (2 Valve) 100KV Light Therapy	10	100	115 230	3 3	6 10	- -	8 8	20 10	30 30
Light Therapy 140 KV.	10	140	115 230	3 3	6 10	- -	8 8	25 15	30 30
Full Wave: (4 Valve) 200 MA.	200	100	230	15	4	6	8	70	100
300 MA.	300	100	230	25	1	4	8	120	200
500 MA.	500	100	230	25	00	3	6	180	200
1000 MA.	1000	100	230	50	300000 C.M.	0	4	350	400
Three Phase: 500 MA.	500	100	230	3-15	3	4	8	100	200
1000 MA.	1000	100	230	3-25	00	3	6	200	200
Deep Therapy: Villard-15 MA.	15	200	230	5	8	-	8	30	30
Villard-30 MA.	20	220	230	7.5	8	-	8	40	60
Const. Potential	15	220	230	10	6	-	8	50	60
Self Contained 8 to 10 MA.	10	200	230	15	6	-	8	60	60
Self Contained 15 MA.	15	220	230	15	4	-	8	60	60
400 KV.	5	400	230	15	6	-	8	60	60

To avoid poor results from voltage drop, it is good practice in a large department to concentrate the high capacity work as far as possible in one radiographic room so as to minimize the possibility of several high capacity exposures being made at the same instant.

Another source of difficulty is to forget about various electrical appliances drawing current from the same transformer. Very often when all of these are traced and added up, the accumulated load will be excessive, at least from the standpoint of X-ray.

The requirements for the mobile units are very modest, but here too good line capacity will be very helpful to secure best results. It is common to plug the X-ray machine into any lamp socket. Occasionally this socket will have an excessively long supply line and a light fuse. Consequently there will then be a voltage drop, or possibly a blown fuse and,in any event, liklihood of an underexposed film. Use 25-30 ampere fuse for 30 M.A. units.

A good modern practice is to call for a special circuit for mobile X-ray equipment, particularly in orthopedic and chest wards.

A FEW INSTALLATION POINTERS

(a) Store room; this is often forgotten or given insufficient space.

(b) Film files. Storage space is often insufficient.

(c) Size and ventilation of Dark Room. The frequent presence of refrigerating machinery and much moisture makes for heat and humidity. Ventilation should be carefully planned for and in hot climates air conditioning is advisable, not only for the comfort of personnel but to reduce film deterioration.

(d) Fluoroscopic room. In large institutions, a good many hours will be required for fluoroscopy which means that a number of persons must be "cooped-up" in this room for long periods. The ventilation and perhaps air conditioning are correspondingly important. Poor ventilation often causes untoward symptoms, usually blamed wrongfully on exposure to the Roentgen ray.

Provision of a barium kitchen conveniently located should not be overlooked.

Still more important, a "head" must be located conveniently to the fluoroscopic room (barium enema).

(e) Dressing room. More are needed than is apt to be thought at first glance. This is especially true now that the number of female patients is constantly increasing. A shortage of dressing room space will notably slow down the work. The matter of placing small mirrors in most of these dressing rooms should not be overlooked, likewise chairs, costumers and clothes hooks.

(f) Toilet facilities. These should be ample.

(g) Control booths. Ventilation, visibility and means of communication should

be considered as well as protection. If proper use of the booth is awkward, unsafe practices are apt to develop.

(h) Radiographic rooms. It is worth while to provide cabinet space for storage of cones, sand bags, calipers and various odds and ends of equipment; a good work table is also needed.

(i) Stenographic work. Typing of reports is often done in one of the general offices or viewing rooms of the X-ray suite usually without particular difficulty. However, when the volume of work becomes large, it will be found best if a separate and conveniently located office can be provided for the typist because it will require a full day of uninterrupted work to keep up.

A dictaphone will usually prove a very profitable investment.

ELECTRONIC TUBES

Multiple Element Tubes: The valve tubes already described are of course a simple form of electronic tube used to rectify and transmit current. It has been found that by introducing added elements, current control becomes possible. The first step in modifying electronic tubes is the introduction of a third element or grid. A wire mesh grid placed between the anode and cathode and charged negatively relative to the cathode, (negative charge greater than that of cathode), will diminish the flow of electrons and if the charge is sufficiently great will entirely block electrons. The usual negative charge on the grid is its characteristic operating "bias" and prevents passage of an excessive amount of current. Variations in the charge on the grid produce very marked fluctuations in the current passed through the tube and makes possible its use as an amplifier. For instance, a minute A. C. voltage applied to the grid will result in a large A. C. pattern in the plate current.

A difficulty with the triode is that it forms a condenser-like system which builds up electrostatic charges known as interelectrode capacitances. These will at times form a coupling between the input and output circuits causing instability and irregular operation.

Tetrode: To overcome the difficulty just noted designers have produced the tetrode. The fourth element in this tube is a screen grid to act as an electrostatic shield reducing the grid plate capacitance or condenser effect. This screen has a positive charge but its mesh is so coarse that electrons are not prevented from passing through to the plate.

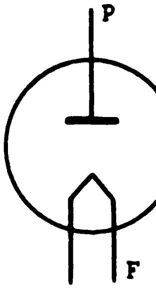
The tetrode tube also has a difficulty which is overcome by using a fifth element. Electrons bombarding the plate produce some secondary emission which is attracted to the positive grid thus reducing the plate current, particularly if the plate voltage drops below the screen voltage.

Pentode: To cope with this difficulty, a fifth element - a negatively charged grid is placed between the screen grid and the plate. It is frequently connected directly to the cathode and commonly referred to as the suppressor, as it repels the secondary electrons back to the plate. This feature of the pentode makes it excellent for high power output with low grid-driving voltage. It is also used in the first

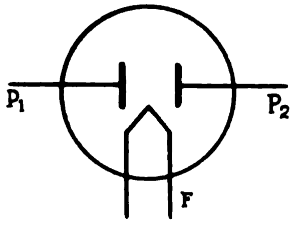
stage of amplification to prevent undesired coupling between input and output circuits.

The thyratron is a gas type tube used for activating relays and so is a "trigger" tube. See Morgan timer and diagram.

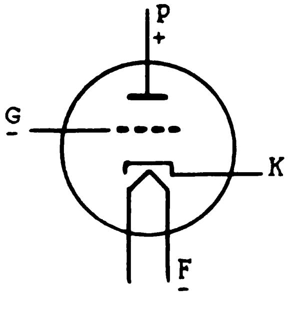
COMMON TYPES OF ELECTRONIC TUBES



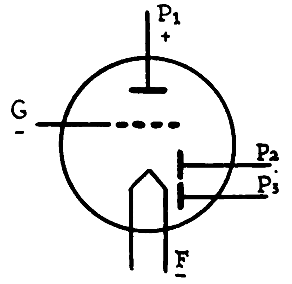
Diode.
Two element tube - Plate and filament (cathode).
Half wave rectifier type.



Duo-diode.
Two plates and one filament (cathode) - equivalent to two diodes for full wave rectification.



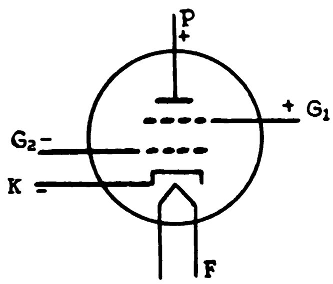
Triode.
Three element tube - Plate, control grid, cathode. The filament heats the cathode to emission.
Used for amplification.



Duo-diode-triode.

Three plates, one grid and filament (cathode).

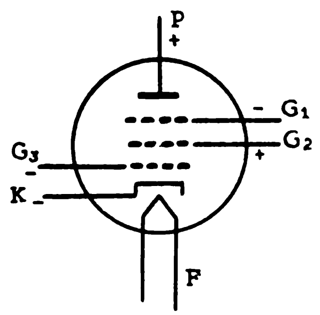
Action of three tubes combined in one - (1) detector; (2) automatic volume control; (3) amplifier.



Tetrode.

Four element tube - Plate, screen grid, control grid and cathode.

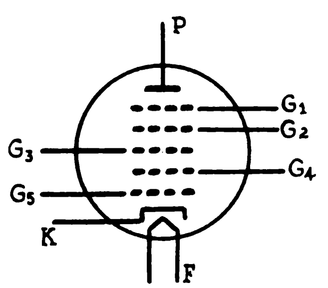
Higher amplification stability than triode due to lower inter-electrode capacity.



Pentode.

Five element tube - Plate, suppressor grid, screen grid, control grid and cathode.

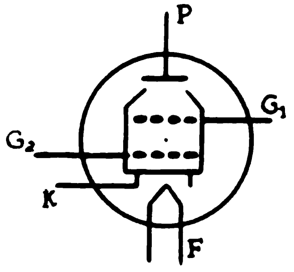
High voltage amplification and higher power output with low grid input voltage.



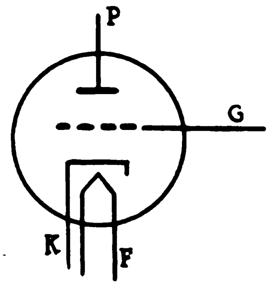
Penta-grid converter.

Five grid - seven element tube. Plate, suppressor grid, screen grid, control grid, oscillator plate, oscillator grid and cathode.

Frequency mixer and conversion.



Beam power tube.
Plate, screen grid, control grid and cathode.
High power output, sensitivity and efficiency.



Thyratron, or Gas triode.
Plate, control grid, cathode and filament.
Shaded or black dot indicates a gas tube.
"Trigger" type tube used in control circuits. When the potential or grid is driven less negative or more positive the tube will pass current or "fire"; this current can be used to close relays in other circuits.

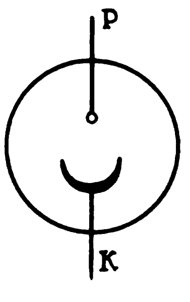
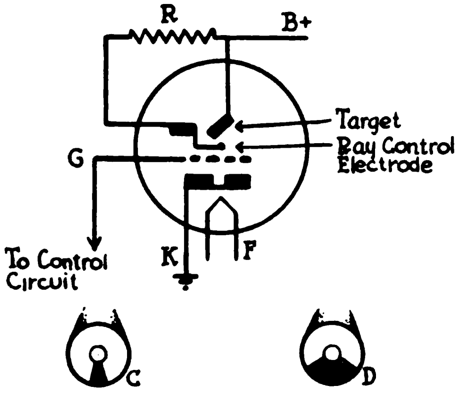
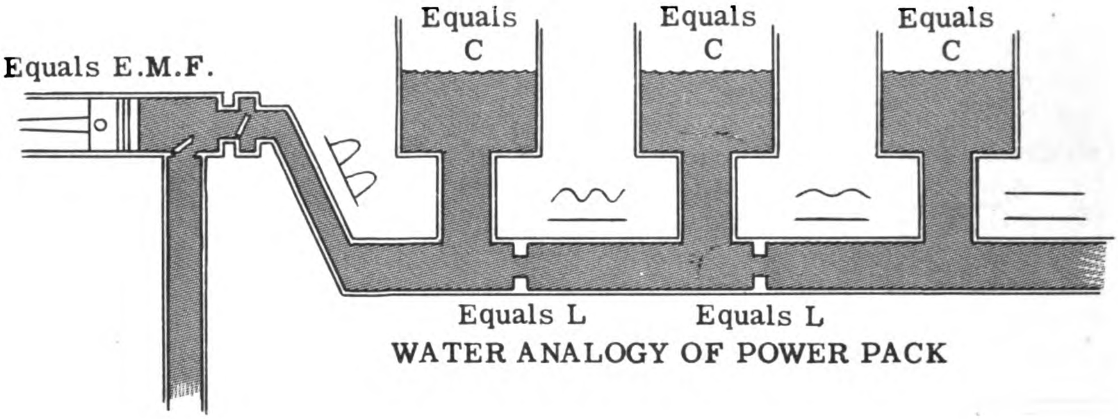


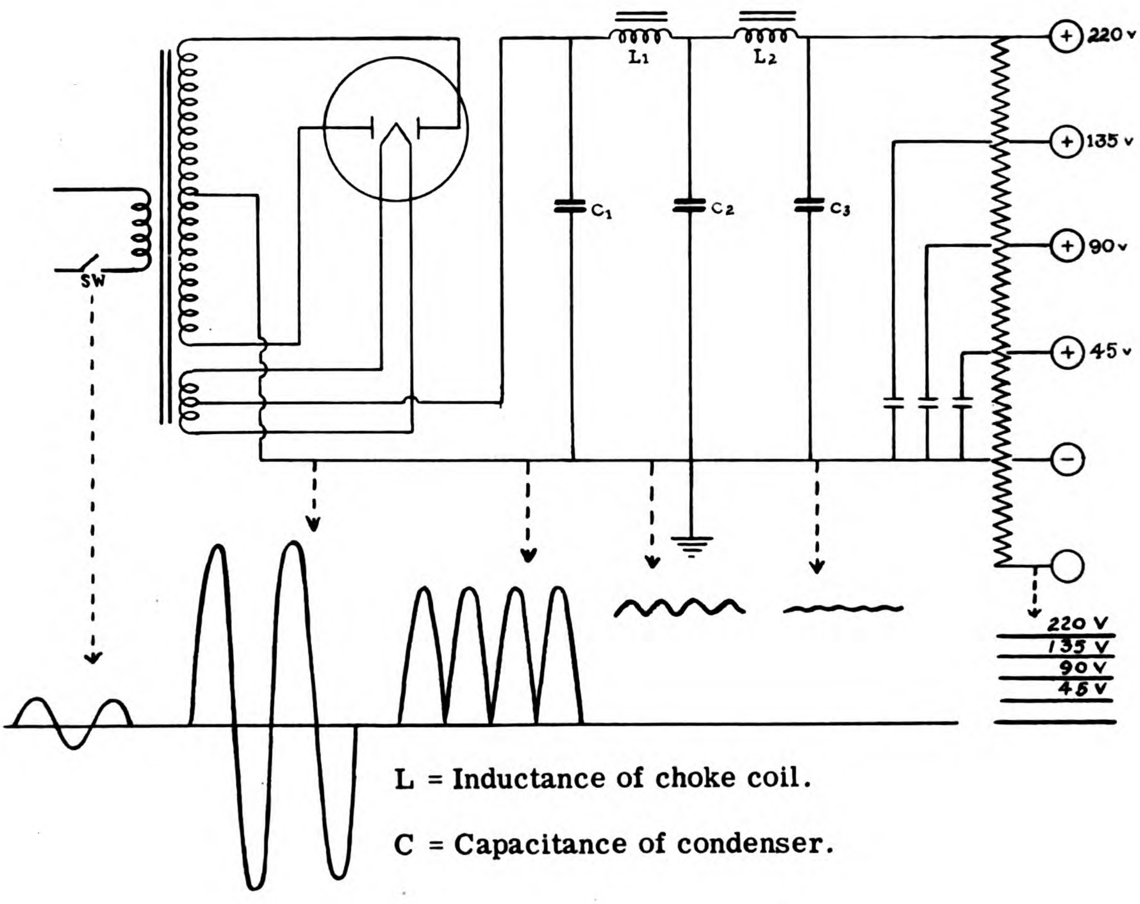
Photo tube.
Plate and photosensitive cathode.
This tube is non-conductive in dark, if light strikes the cathode, it will emit electrons and the tube becomes conductive to an extent depending on the amount of light, and characteristics of the tube.



"Magic Eye" Cathode-ray type tuning indicator.
Use: (a) to indicate resonance; (b) any change in current in control circuits. When control grid G increases in negative bias "Eye" responds as at C, and as grid decreases negative potential, the "Eye" widens, D.



WATER ANALOGY OF POWER PACK



L = Inductance of choke coil.

C = Capacitance of condenser.

POWER PACK

POWER PACK

When alternating current is changed to direct current simply by rectifying tubes, the current will still show a marked ripple effect. To smooth out this current entirely and also make possible variations in its voltage a power pack is made use of. This consists of a transformer, valve tube rectifier (full-wave), condensers, choke coils and resistors as diagramed. It operates as follows:

The A.C. current is passed through a step up transformer and full-wave rectifier. After which it is passed through choke coils interspaced with condensers. The condensers charge on the voltage increase and discharge on the decrease while at the same time the choke coils oppose any change in current. As a result the current is smooth.

A resistance is placed across the line and serves as a "bleeder" and voltage divider by use of a series of taps indicated in the diagram. The more resistance shunted the higher the voltage.

Three small condensers on the output side serve as stabilizers by preventing voltage drop through their reserve capacity.

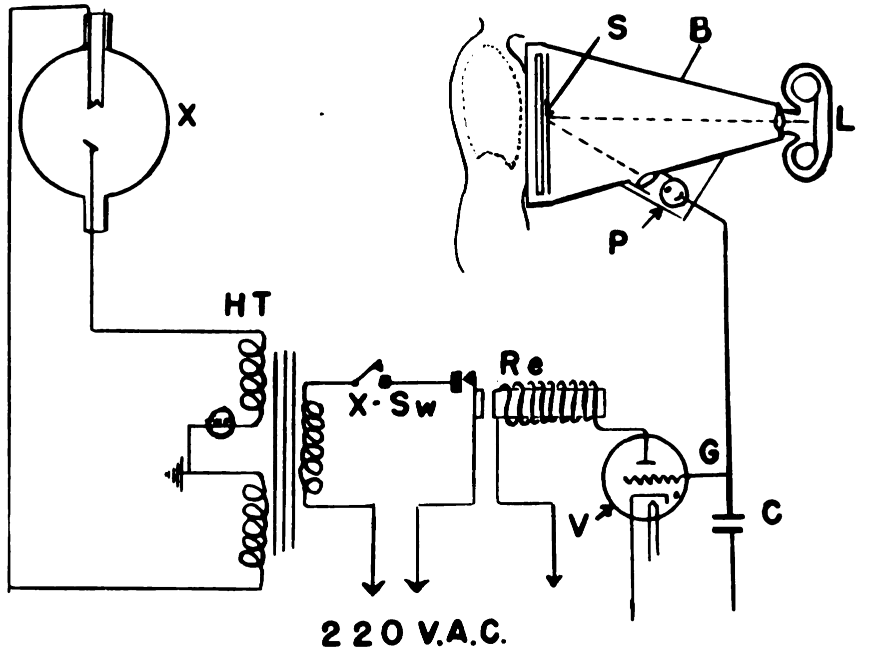
This system also makes possible a negative voltage or "bias" which is essential for proper functioning of multiple element electronic tubes.

MORGAN AUTOMATIC TIMER

This is designed to control automatically the length of exposures so as to produce uniform and properly exposed radiographs. Operation depends fundamentally on the effect of X-ray induced illumination from an intensifying screen upon a photoelectric cell.

Operation: When X-ray switch (Sw) is closed, X-rays are produced and strike the fluorescible screen (S) which then gives off visible light. This activates the photo-electric cell (P) making it conductive. Electrons will now flow from the condenser (C) and the thyratron grid (G) thus reducing the negative bias. It should be borne in mind that it is the negative potential on this grid which prevents the tube from passing current. Once this negative charge has leaked off to a given amount (depending on the characteristics of the tube) the thyratron will pass current or "fire". This current flows through the relay (Re) and opens the X-ray contact. Since the current factors required to "fire" the thyratron tube remain constant and since these factors can be related quantitatively and adjustably to the quantity of illumination of the intensifying screen, it can readily be seen that X-ray exposure can be automatically controlled. Naturally, in the case of a thin individual, the required amount of illumination will be attained more rapidly and the exposure terminated more quickly than in the case of a stout individual.

In the case of conventional radiography there are at present certain handicaps due to the materials in plate holders and cassettes. The backs of these are all more or less impervious to X-ray and so intercept the radiation which must reach the control device if it is to operate. Very likely at some time in the future it will become possible to obtain such cassettes and holders as will make the device operable



MORGAN PHOTO-TUBE TIMER

X, X-ray tube; B, pyramid of photofluorograph; S, fluorescent screen; L, Camera; P, phototube; C, condenser; V, thyratron; G, thyratron grid; Re, relay; X-Sw, exposure switch of X-ray machine; HT, X-ray transformer.

for conventional radiography.

However, in the case of fluorography this difficulty does not apply. By means of a lens located in the bottom of the pyramidal box which houses the fluoroscopic screen and camera unit, an optimal zone of the fluoroscopic screen is focused on the screen of the timing device, thereby making its operation possible.

Fairly extensive experience already indicates that the device is well worth while. Results are more uniform and one less person is required to operate the fluorographic installation. In practice, one simply makes use of one or two fairly high kilovoltage values and lets the timer do the rest.

EXPOSURE METER.

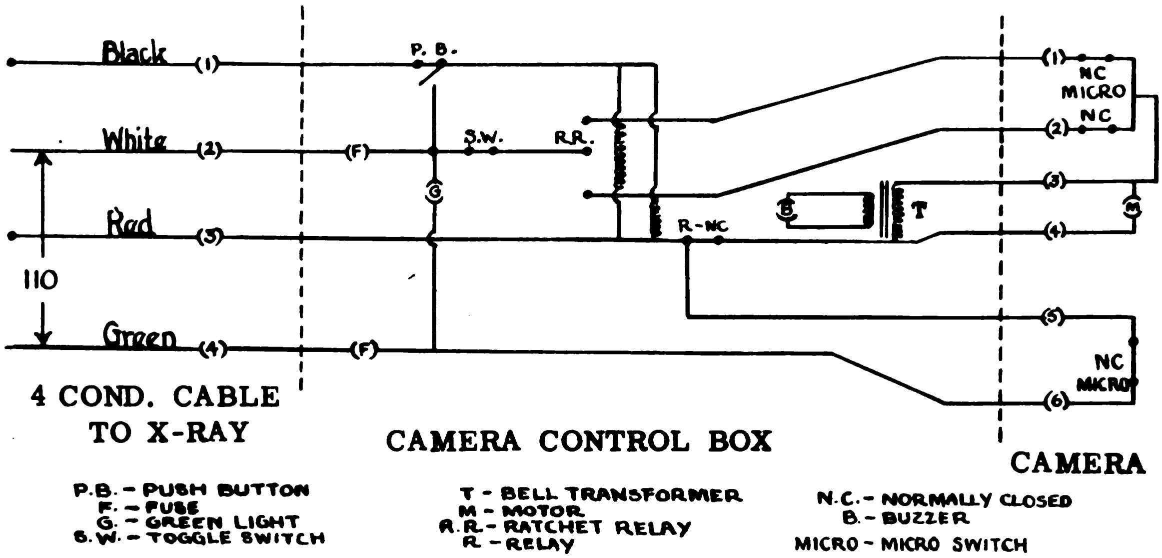
This is a device for determination of the proper exposure time. It is used prior to the taking of a radiograph and indicates the proper exposure time in seconds. It is adaptable by means of a simple switch to use with film either in plain holders or between intensifying screens. One of these has been installed and tested in the U. S. Naval Hospital, Bethesda, Md. It is quite accurate, provided it is placed in precisely the correct location. It is thought that it should be of marked benefit in establishing and testing techniques and in determining exposure time whenever circumstances are at all unusual. In a busy department it is not thought necessary or advisable to use such a timer for each and every exposure as this would occasion too much loss of time.

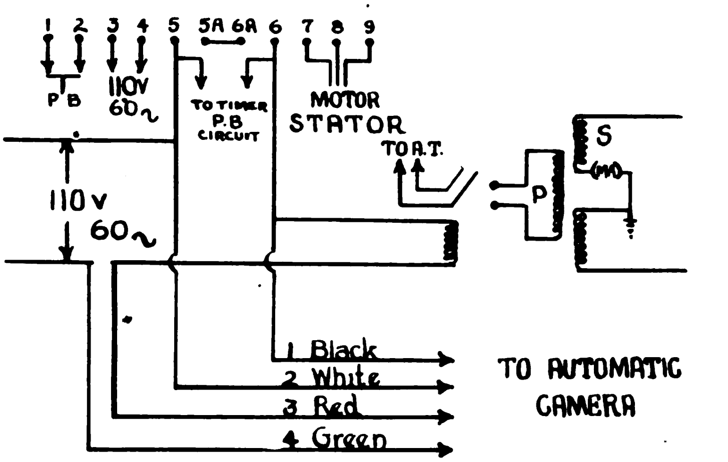
The operating principles of this meter are fundamentally the same as the timer except that the current flow made possible by the operation of the photo-electric cell, is used to provide a meter reading instead of opening the X-ray circuit.

COMMON LOGARITHMS OF NUMBERS
Four Decimal Places

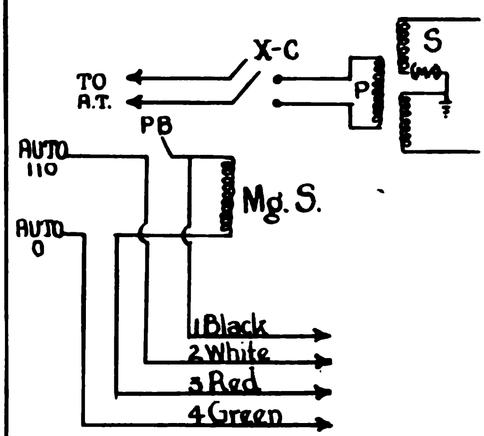
1 - 100

N	Log	N	Log	N	Log	N	Log	N	Log
0	———	20	1.3010	40	1.6020	60	1.7781	80	1.9030
1	0.0000	21	1.3222	41	1.6127	61	1.7853	81	1.9084
2	0.3010	22	1.3424	42	1.6232	62	1.7923	82	1.9138
3	0.4771	23	1.3617	43	1.6334	63	1.7993	83	1.9190
4	0.6020	24	1.3802	44	1.6434	64	1.8061	84	1.9242
5	0.6989	25	1.3979	45	1.6532	65	1.8129	85	1.9294
6	0.7781	26	1.4149	46	1.6627	66	1.8195	86	1.9345
7	0.8451	27	1.4313	47	1.6721	67	1.8260	87	1.9395
8	0.9030	28	1.4471	48	1.6812	68	1.8325	88	1.9444
9	0.9542	29	1.4624	49	1.6902	69	1.8388	89	1.9493
10	1.0000	30	1.4771	50	1.6989	70	1.8451	90	1.9542
11	1.0413	31	1.4913	51	1.7075	71	1.8512	91	1.9590
12	1.0791	32	1.5051	52	1.7160	72	1.8573	92	1.9637
13	1.1139	33	1.5185	53	1.7242	73	1.8633	93	1.9684
14	1.1461	34	1.5314	54	1.7323	74	1.8692	94	1.9731
15	1.1760	35	1.5440	55	1.7403	75	1.8750	95	1.9777
16	1.2041	36	1.5563	56	1.7481	76	1.8808	96	1.9822
17	1.2304	37	1.5682	57	1.7558	77	1.8864	97	1.9867
18	1.2552	38	1.5797	58	1.7634	78	1.8920	98	1.9912
19	1.2787	39	1.5910	59	1.7708	79	1.8976	99	1.9956
N	Log	N	Log	N	Log	N	Log	N	Log





DYNAMAX STARTER FOR ROTATING ANODE



CONVENTIONAL FOR STATIONARY ANODE

ELECTRICAL CIRCUIT, AUTOMATIC CAMERA:

The leads #3 and 4 are in series with the magnetic switch through the micro switch in the camera - this prevents X-ray exposure after the film supply is exhausted.

Lead #2 connects to autotransformer, 110 volt stud; #4 to autotransformer zero (0) stud. (In circuits supplied as above).

Caution: Leads 3 and 4 must be on the same side of magnetic switch to prevent shorting 110 volts across the micro switch in camera.

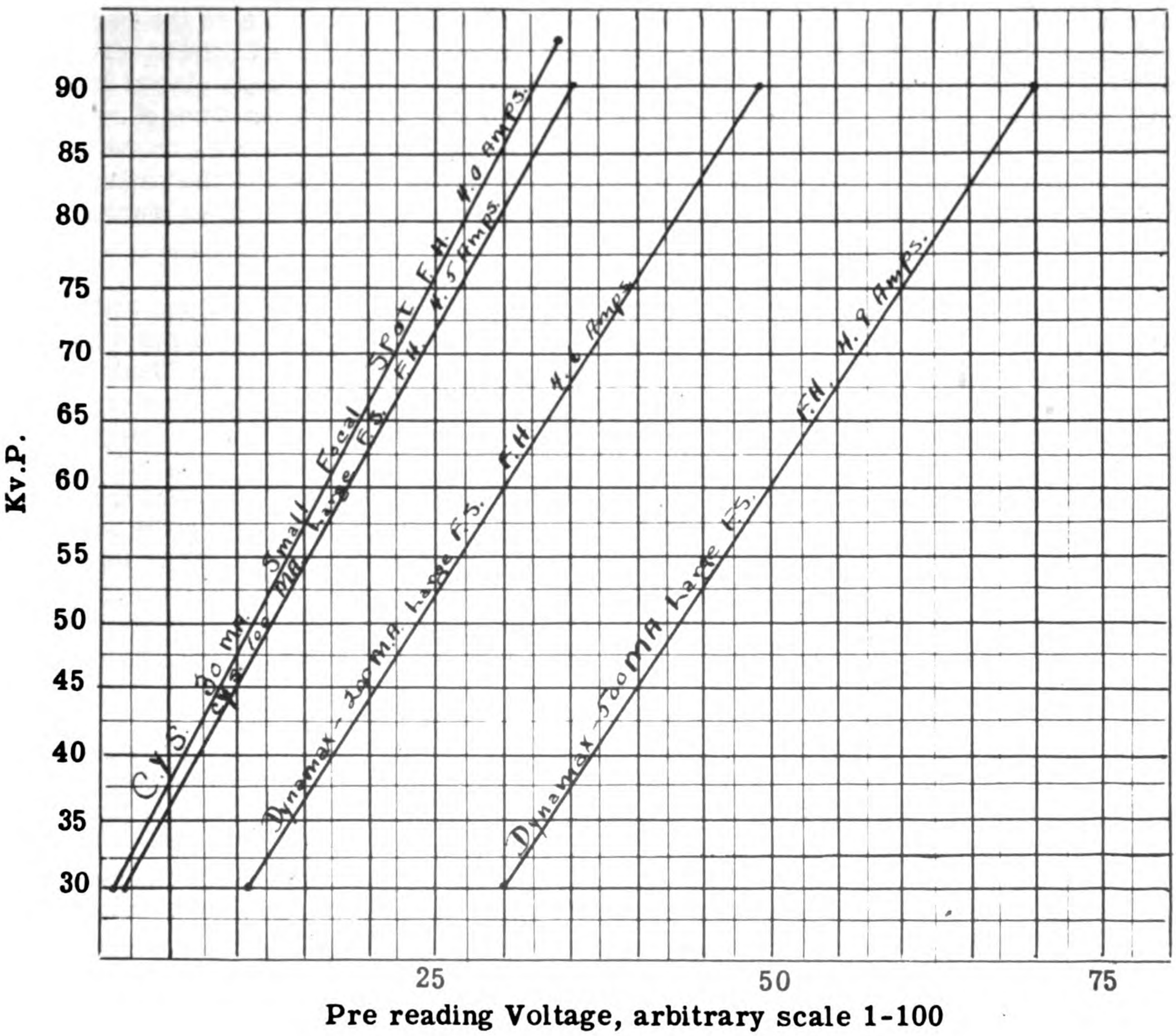
Note: In case of emergency, #2 and 4 may be plugged into 110 A.C. 60 cycle wall switch and push button on camera used to advance film.

REPLENISHMENT SYSTEM - PROCESSING SOLUTIONS

Where the volume of work is great, it will often be found useful to apply a constant replenishment system to both developing and fixing. A small amount of each solution flows slowly and continuously into the appropriate tank. With proper quantitative adjustment, no complete change is needed over a period of many months.

It is best to allow a gallon of developer for each forty (40) - 14 x 17 inch films or equivalent.

KILOVOLTAGE CALIBRATION CHART



Notes on Clerical Procedures:

There must always be some system as to making and filing X-ray reports and for filing films. There are many of such. In general a work book in which all patients are logged when they are radiographed is desireable along with various files. A good procedure is as follows:

The patient is first logged and assigned a serial file number. This file number is written on the request form and an exposure or technique card filled out. (See illustration on page 65). This card should contain name, status, age, sex, height, weight, etc. The exposure card is clipped to the request form and sent with the patient to the radiographic room. After the films are processed the technique card is attached to them along with the filing jacket for the films. When the films are read the roentgenologist will thus have at hand all the pertinent data as to the exposure factors, and correction of any errors becomes easier. As to the reports, an original and two copies are usually desired. The original goes to the medical officer who requested the work, a duplicate is filed and the final copy placed in the filing jacket along with the films. In addition cards are made at the time of reading to cover the anatomico-pathological file. The technique card goes back to the admission office where it is filed and can be readily pulled when and if the patient returns for more radiography. Each patient keeps the same file number during the calendar year.

Whenever films are loaned out a receipt should be obtained for them and an entry made in a book kept for that purpose. Films should not be loaned out without the consent of the medical officer in charge of the department. The films are the property of the X-ray department and not of the patient, even though he or she may have paid for the examination. It has been decided legally that what the patient pays for in an X-ray examination is the expert opinion of the roentgenologist and that the films are the means to that end. In other words, the X-ray examination is a professional consultation. Films are loaned out for the purpose of additional professional consultation and at times when the patient is transferred to another activity. Films may not be loaned out to other parties without the patient's consent. When films are desired for presentation in civil courts the matter should be handled in proper manner by formal request through the commanding officer of the naval hospital or other activity.

When patients desire to see their films, they should be referred to their own physician or medical officer for written permission. Many times it is highly undesirable for patients to view their films.

When patients ask questions as to the X-ray findings considerable caution is necessary. In general they should always be referred to their own doctor who will have the roentgenological report and also his own clinical knowledge to use as a basis in discussing the situation. With a little tact it is usually possible to send the patient away satisfied with some non-commital statement and the information as to when his own doctor will have the full report to discuss with him.

Considerable caution is also needed in giving reports over the phone particularly in the case of important personages. Be sure that the person requesting the

information is entitled to have it. When in doubt the matter should always be referred to the head of the department.

Organizing the work of a busy department is always something of a problem and each activity will have somewhat different conditions to meet. The following work schedule is listed merely as a sample specimen and starting point. It has proven fairly satisfactory in actual use. If copies of the work schedule, along with explanatory notes and suggestions,are sent to all activities concerned, it will help to expedite work and prevent misunderstandings.

WORK SCHEDULE FOR THE X-RAY DEPARTMENT

RADIOGRAPHY

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0830 to 1200	G.I.Series & Barium Enema	G.I.Series & Barium Enema	G.B. Vis. myelograms spec. fluor-oscopy	G.I.Series & Barium Enema	G.I.Series & Barium Enema	G.B. Vis. myelograms spec. fluor-oscopy	EMERGENCY
	ALL THE ABOVE EXAMINATIONS BY APPOINTMENT ONLY						
	Routine House Cases and Special Appointment Cases						
1200 to 1300	LUNCH HOUR Emergency Cases and Special Appointments						
1300 to 1500	Out-Patient and by Special Arrange-ment	Out-Patient and by Special Arrange-ment	Out-Patient and by Special Arrange-ment	FIELD DAY EMERGENCY CASES	Out-Patient and by Special Arrange-ment	Special Appoint-ment Cases and Emer-gency Cases.	WORK ONLY

For routine appointments and information call telephone extension -
For special appointments call telephone extension -

THERAPY

All House Cases and OPD cases for X-ray Therapy are scheduled in the X-ray department and treatments are carried out all through the regular working hours.

It is necessary to have approval of a Medical Officer of the X-ray department before treatment may be given.

(Work schedule continued on next page)

For initial examination and prescription of treatment the hours are:

1000 to 1130 daily, except Sunday.
1300 to 1500 daily, except Thursday, Saturday and Sunday.

Note:

The period between 1500 and 1630 is not covered in the chart. It can be well used for completing radiographic work on late comers, clearing up dark room work, inspection, sorting and filing of films, instruction periods in technique and finally for cleaning the department, etc.

Naturally when work is heavy, radiographic work will extend throughout all time available and much of the sorting and filing of films will fall to the lot of personnel on watch in evening hours.

GENERAL

1. Form 57 (Special Examination and Request for Treatment) should be filled out completely, accurately and legibly in every case for radiography or Roentgen therapy. This is an obvious essential needed to prevent confusion, delay and filing errors; none the less gross carelessness here is frequent.

Since in most respects Roentgen diagnosis and therapy constitute professional consultations, statements as to condition suspected, or to be ruled out, are not only proper but also an aid in having proper views made and in obtaining a report sure to cover the point at issue. Naturally pertinent clinical data should not be omitted, especially in the case of therapy.

2. Work must be done in accordance with the regular schedule as far as possible. This is in the best interests of all concerned and not merely for the convenience of the X-ray department.

3. Emergency and such cases as may need other than routine attention will be taken care of at any time by special arrangements. Request slips should then be marked "Emergency", "Special" (State type of service desired) or "Reading desired by____________"(State time). They should be initialed by the Medical Officer concerned to guarantee correctness and authenticity. When such is impracticable, for any reason, the Medical Officer (or some responsible assistant,in case of necessity) should phone the Department.

It should be remembered that abuse of emergency service is not only an imposition, but obviously will tend to interfere with best results.

4. Give earnest thought to film economy. Films are expensive and also involve use of materials which are "critical" in war time.

ADDITIONAL READING

1. MANUAL OF ROENTGENOLOGICAL TECHNIQUE. (Listed on Supply Table).
   L.R. Sante. Published by Edwards Brothers, Inc., Ann Harbor, Mich.
   Includes material on planning and a useful glossary.

2. ROENTGEN TECHNIQUE.
   McNeill. Published by Chas. C. Thomas, Springfield, Ill. and Balto.,Md.
   Very convenient small volume with main emphasis on positioning.

3. POSITIONING IN RADIOLOGRAPHY.
   K.C. Clark, F.S.R. Published by C.V. Mosby Co., St. Louis, Mo.
   An encyclopedic work with numerous illustrations. A beautiful publication.

4. MEDICAL RADIOGRAPHIC TECHNIQUE.
   General Electric X-ray Corp. Published by Chas. C. Thomas, Springfield, Ill. and Baltimore, Md.
   Good material well illustrated.

5. OUTLINE OF MODERN X-ray TECHNIQUE.
   Picker X-ray Corporation, 300 Fourth Avenue, New York, N.Y.
   Material well presented but lacks an index.

6. ROENTGENOGRAPHIC TECHNICIANS TECHNICAL MANUAL #8-240.
   War Department.

7. MODERN PHYSICS OF ROENTGENOLOGY.
   Muncheryan. Published by Wetzel Publishing Co., Inc. Los Angeles, California.
   Also covers processing and technique.

8. PHYSICAL FOUNDATIONS OF RADIOLOGY.
   Glasser, Quimby, Taylor and Weatherwax. Published by Paul B. Hoeber, Inc., Book Dept., Harper & Bros., New York and London.
   Modern book with excellent consideration of therapy.

9. RADIOLOGIC PHYSICS.
   Warren Weyl and O'Neill. Published by Chas. C. Thomas, Springfield, Ill. and Baltimore, Md.

10. FLUOROSCOPES AND FLUOROSCOPY. (Carman Lecture).
    W. E. Chamberlain, M.D., Radiology, April, 1942. Radiological Society of North America, 607 Medical Arts Bldg., Syracuse, N.Y.

11. SWOOPE'S LESSONS IN PRACTICAL ELECTRICITY.
    Hausmann. Published by D. Van Nostrand Co., New York.

12. EXPERIMENTAL ELECTRONICS.
    Muller, Garman and Droz. Published by Prentice Hall, Inc., New York.

The following periodicals frequently contain much valuable material from a technical standpoint.

1. AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY.
   Published by Chas. C. Thomas, Springfield, Ill. and Baltimore, Md.

2. RADIOLOGY.
   Published by Radiological Society of North America, 607 Medical Arts Building, Syracuse, New York.

3. THE X-RAY TECHNICIAN.
   Journal of the American Society of X-ray Technicians, Bruce Publishing Company, St. Paul, Minn.

4. RADIOGRAPHY & CLINICAL PHOTOGRAPHY.
   Published by Eastman Kodak Company, Rochester, New York.

GLOSSARY

a or an - prefix, meaning a lack of; as, atonic - lacking tone.
ab - prefix, meaning from.
abduct, to move away from the mid-line, as to abduct an extremity.
abscess, an infected area containing pus.
accessory, additional or supplementary.
acetabulum, the cavity of the hip joint.
achondroplasia, developmental disease causing marked shortening of the long bones.
acoustic nerve, same as auditory nerve.
acromegaly, overgrowth of the facial bones and hands due to pituitary disease or tumor.
acromion process, a large process on the upper part of the scapula.
actinic, types of radiation which affect photographic emulsions.
actinomycosis, fungus infection.
ad - prefix, meaning toward.
adenopathy, enlargement of glands.
adipose tissue, fat.
aerated, filled with air.
air-bells, small clear circular areas on the finished film due to bubbles of air on the emulsion during development.
alignment (or alinement), the linear relation of a series of objects, e.g. vertebral.
alkaline, active chemical characterized by liberation of hydroxyl ions ($\overline{OH}$) in aqueous solutions.
alpha particle, a helium atom minus two electrons. It is given off by certain radioactive substances.
alveolar process, bony ridge in which the teeth are lodged.
alveolus, terminal air sac of the lungs.
amorphous, without regular form or structure.
angioma, blood vessel tumor.
aneurysm, distention or pouching of a blood vessel.
anion, negatively charged ion.
ankylosis, complete loss of all motion in a joint.
anomaly, an unusual structural variation.
anterior, parts toward the front of the body.
anti-cathode, anode or target of an X-ray tube.
antrum,(or maxillary sinus), cavity in the cheek bone normally filled with air.
aorta, large artery which carries the blood from the heart.
apex (plural - apices), the top of tip of a pyramidal structure; the tip of the lung.
arachnoid, thin membranous cover for the brain.
arceline, refers to special angled views for the petrous pyramids.
arteriosclerosis, thickening and hardening of the arteries.
arthritis, inflammation of a joint.
articular facets, smooth rounded surfaces for articulation.
articulation, a joint.
artifact or artefact, marks on an X-ray film due to accidents in handling or processing film.
asthenic, lacking in robustness; long and thin.
astragalus (Talus), tarsal bone.
atelectasis, unaerated condition of lung.
atresia, the complete contracture of a tube or passage.
atrophic, wasted.
auditory meatus, opening of the ear.
axilla, arm pit.
azygous, unpaired; (also azygos).

ballistic milliampere meter, device for registering MAS in short high-capacity exposures.
Bennet's fracture, involves the upper or proximal end of the thumb's metacarpal.
Benoist penetrometer, a circular metallic ladder made of increasing thicknesses of aluminum, from 1 to 10 mm.
beta rays, streams of electrons from radioactive substances.
bifurcate, division into two branches.

bi - prefix, meaning two.
bilateral, both sides.
blastomycosis, a fungus infection.
bronchiectasis, dilitation of the bronchi.
bronchioles, tiny subdivisions of the bronchi.
bronchogenic, of bronchial origin.
bunion, thickened bursa over the great toe.
bursa, a thin sac containing fluid and overlying bony prominences or tendons to prevent friction.
buttock, the gluteal prominence.

calcaneus, os calcis.
calculus, stone.
callus, reparative material produced by broken bones.
calyx (plural - calices), small branching extensions from the renal pelves.
cancellous bone, the spongy portion in the ends of long bones.
cancer, malignant new growth of epithelial cells.
capitellum, articular eminence of the humerus for the head of the radius.
cardiospasm, spasm of the lower end of the esophagus.
caries, decay of bone.
cascade stomach, stomach with a large pouch in the fundus from which ingested material spills over in "cascades". Also called "cup and spill" stomach.
catheter, small rubber tubes for insertion into the bladder or other cavity. For radiography they should be opaque to X-ray.
cation, an ion which flows to the cathode.
caudal, toward lower end of the body.
cephalic, pertaining to the head.
cervical, pertaining to the neck.
characteristic radiation, secondary radiation typical of a given element.
cholecystitis, inflammation of the gall bladder.
chondroma, tumor of cartilage.
choroid plexus, network of small blood vessels in the lateral ventricles of the brain.
clavicle, collar bone.
clinoid processes, projections from sella turcica.
coccyx, the caudal end of the spine.
colitis, inflammation of the colon.
colostomy, artificial opening into the colon.
Colles' fracture, fracture of the lower end of the radius.
coma, unconsciousness.
condyle, a rounded projection on a bone to help form an articulation.
condyloid process, articular process of mandible.
congenital, present at birth.
coracoid process, hook-like projection from the scapula.
corona, brush-like discharge of a high voltage electric current.
coronal plane, frontal plane, or plane parallel to the front of the body.
coronoid processes, (a) anterior lip of the ulnar articulation with the humerus. (b) anterior projection from upper end of the mandibular ramus.
corpus, body or main portion of an organ.
costal, concerning the ribs.
costophrenic angle (or sinus), the angle formed by the ribs and the diaphragm.
counter electromotive force, E.M.F., induced E.M.F. producing impedance.
cranial, pertaining to the head.
crest, a ridge of bone.
cuboid, tarsal bone.
curie, the quantity of radon in equilibrium with one gram of radium.
cyst, encapsulated collection of fluid.
cystogram, view of the urinary bladder after injection of a contrast medium.

decubitus, lateral, patient lying on side.
deglutition, swallowing.
desiccated, anhydrous or dry.
deuteron, nucleus of a hydrogen atom.
diamagnetic, non-magnetic.
diaphysis, shaft of a long bone.
diastole, relaxed or resting stage of cardiac cycle.
diploetic, referring to loose bony tissue of outer and inner tables of the skull.

discrete, clear cut.
distal, away from the central part of the body.
diverticulum, outward pouching from a hollow organ.
dorsal, pertaining to the back.
duodenum, first portion of the small intestine.

edema, seepage of clear fluid into tissues.
edentulous, without teeth.
effusion, abnormal collection of fluid in a body cavity.
electrode, terminal of a conductor of electricity, usually of metal or carbon.
electroscope, an instrument for the detection of small charges of electricity.
emanation, (in radiology), gaseous degeneration product of radium resulting from the emission of an alpha particle; radon.
embolus, a fragment of a blood clot or other material free in the circulatory system.
emphysema, distension of the tissues with air; pulmonary - overdistension of air sacs with air; subcutaneous - distension of subcutaneous tissues with air.
empyema, pus in the pleural cavity.
encephalography, roentgenography of the brain after replacement of spinal fluid by air (spinal tap).
ensiform process, (xiphoid), small triangular bony segment forming the lower end of the sternum.
epicondyles (of the humerus), the small bony processes on the humerus just above the elbow joint.
epiphysis, growth center at the end of a long bone.
erosion, necrosis of the edge of a solid structure such as bone.
ether-hypothetical, medium,thought to pervade all space and serve as a means for transmission of radiation.
ether-pharmaceutical, liquid used for general anesthesia.
ethmoids, the air cells adjacent to the nasal cavity.
etiology, cause of a disease.
eversion, outward rotation.
ex - prefix, meaning out or away from.
exostosis, an outgrowth of bone.
extra - prefix, meaning outside of.
extravasation, escape of blood, or other body fluids into the surrounding tissues.
exudate - fluid or plastic material resulting from the reaction of blood vessels and tissues to disease.

facet, smooth area on a bone for articulation.
fallopian tube (oviducts), extend from uterus to ovaries.
falx cerebri, vertical membrane between the two sides of the brain.
fat-free meal, one free from fat; used in preparation for gall bladder visualization.
fat-meal, one containing fat; used to empty the gall bladder in the Graham-Cole gall bladder test.
fibrosis, replacement of normal tissues with fibrous tissues.
filter, a sheet of metal through which rays go before striking the area to be examined or treated.
fistula, a false tract into the tissues.
flaccid, limp or flabby.
flatus, gas in the intestines.
flexure, a bend; as, hepatic flexure of the colon.
fluorescence, the emission of light from crystals of calcium tungstate, etc. when they are acted upon by X-rays. It is this property which makes the fluoroscopic screen possible.
fontanelle, soft spot in a young baby's head.
foramen, opening in a bone for vessels, nerves and other structures.
fossa, concave depression in a bone.
frontal or coronal plane, a plane which divides the body into ventral and dorsal parts.

gall bladder, reservoir for bile.
gamma rays, extremely short wave radiation from radioactive elements.

gangrene, necrosis of tissue.
gastric, pertaining to the stomach.
gastro-enterostomy, operative opening between the stomach and intestines.
gladiolus, the second bony division of the sternum.
glenoid cavity, the scapular part of the shoulder joint.
glenoid fossa, the depression for articulation with the condyle of the mandible.
glioma, type of brain tumor (also from other nerve tissue).
glottis, upper opening of the air passages.
gonads, sex glands.
Graham test (Graham-Cole test), this is for gall bladder visualization.
grain, the degree of coarseness of a screen or film emulsion.
greenstick fracture, incomplete fracture.

habitus, type of personal build.
half-value layer, thickness of a given filter, such as, aluminum, or copper, which will reduce the X-ray beam to one-half of its value.
halides, compounds of metals with the halogen elements, iodine, bromine, chlorine and fluorine.
head band (in radiography), broad muslin band with weights at either end for immobilization.
hemangioma, tumor of blood vessel.
hematoma, collection of blood in the tissues.
hepatic, pertaining to the liver.
heterogeneous, a varied composition.
hilum (or hilus), root of the lung.
Hodgkin's disease, type of lymphoid tumor.
homogenous, uniform throughout.
hydronephrosis, overdistention of kidney pelvis with urine.
hyper - prefix, indicating excessive degree.
hypersthenic, refers to unusually heavy and robust habitus.
hypertonic, increased tonicity.
hypo, common term for fixing bath and for hyposulphite of soda (Sodium thiosulphate).
hypo - prefix, indicating insufficient degree.

idiopathic, refers to pathology of unknown origin.
ileocecal region, where the ileum joins the cecum.
ileum, the third and last portion of the small intestine.
ileus, intestinal distention by gas.
ilium, the flaring portion of the hip bone.
impaction, firm lodgement, as by driving one fragment of bone into another.
infarct, necrotic area caused by blockage of an artery.
infra - prefix, meaning below.
innominate bones, pelvic bones.
inspissated, thickened and dried out.
integrating timer, a timing device which automatically adds up periods of activation; giving the total time of operation of the machine.
inter - prefix, meaning between.
intervertebral disc, elastic cartilage between vertebral bodies.
intra - prefix, meaning into.
inversion, inward rotation.
involucrum, periosteal bone formed to replace destroyed bone in osteomyelitis.
ion, an electrically charged particle bearing either a negative or a positive charge.
ischium, the lower portion of the pelvis; supports the body's weight in sitting.
iso - prefix, meaning the same, or similar.
itis, suffix, meaning inflammation of.

jejunum, second portion of the small intestine.

Kenetron tube, a valve tube for rectification of high voltage current.
kilo - prefix, meaning one thousand.
kymograph, apparatus to record cardiac motion.
kyphosis, curvature of the spine producing "hump-back" deformity.

lag (in radiology), continued light from a fluorescent screen, after exposure to X-ray has ceased.
lambda (anatomical), skull landmark, occipital protuberance.
lambda (physical), Greek letter commonly used to designate wave length in radiation.
laminagraph, apparatus for sectional radiography.
latent image, the invisible effect produced on a film by the action of light or X-rays before development.
lesion, any local pathological condition.
lodestone, piece of natural magnetic iron ore.
lordosis, curvature of the spine with convexity forward.
lues, syphilis.
lumen, the channel of a tubular structure.
luxation, dislocation.
lymph, fluid in which the tissues are bathed.

macroscopic, visible with the unaided eye.
mal - prefix, meaning wrong or improper.
malignant, extremely severe, or virulent.
malleolus, projection of bone at the side of ankle joint.
mammography, radiographic examination of the breasts.
mandible, lower jaw.
manubrium, the upper segment of the sternum.
masks, lead shields to limit the field of examination.
medial, portion or part nearest the midline.
mediastinum, the middle compartment of the chest containing the trachea, esophagus, heart and great vessels.
medullary canal or cavity, hollow portion of a long bone.
meninges, the lining of the spinal canal and skull.
mesentery, fold by which the intestines are attached to the posterior wall of the abdominal cavity.
microcephaly, an unusually small skull.
mobility, movability of a structure, or organ.
motility, rate of motion, as of gastric or intestinal contents.
motor meal, barium sulphate preparation used to investigate the motility of G.I. Tract.
mucosa, mucous membrane.
myocardium, heart muscle.

necrosis, death of tissue.
neoplasm, pathological new growth; tumor.
nephroptosis, abnormally low position of kidney.
nucleus pulposus, elastic body in the discs between the vertebrae.
nutrient artery, in radiology, small arteries supplying bone and producing tiny areas of rarefaction where they penetrate the cortex.

occiput, posterior portion of the skull.
occlusal film, film placed between the occlusal surfaces of the teeth.
occlusion, closure of a passageway or cavity.
olecranon process, the heavy hook-like projection of the upper end of the ulna.
omentum, folds of peritoneum connecting the stomach and transverse colon and hanging down in front like an apron.
opacity, object impervious to radiation of some given type.
oral, pertaining to the mouth.
orifice, opening.
ortho - prefix, indicating normal degree.
osseous tissue, bone.
ossicle, a tiny bone.
osteoma, bone tumor.
oxycephaly, "tower" skull.

palmar, referring to the palm of the hand.
para - prefix, meaning adjacent.
parenchyma, functioning portion of an organ, e.g., air sacs or alveoli of the lungs.
parietal, lateral or outer aspect.
parietal bone, large flat bone forming the greater part of the side of the cranial vault.
pars media, usually refers to the midportion of the stomach.

pathology, science which deals with diseased structures of the body.
pelvimetry, measurement of the pelvis.
peri - prefix, meaning around.
pericardium, membrane covering the heart.
perineum, the region between the pubic arch and coccyx.
persistalsis, wave-like contractions of tubular structures.
periosteum, tough membrane covering the bone.
phleboliths, small rounded calcium deposits in the walls of veins.
photon, a particle of an atom broken off by impact of radiation such as X-ray.
phrenic, pertaining to the diaphragm.
physics, science which deals with matter and energy.
pin-hole radiograph, one taken through a pin-hole in a lead diaphragm to produce an image of the target.
pituitary fossa, sella turcica q.v.
pleura, membrane covering the lungs.
pneumo - prefix, signifying air-containing.
pneumoconiosis, lung disease due to inhalation of dust of any kind.
Pott's fracture, fracture of the lower end of the fibula.
process of bone, a projection of bone.
pronation, rotation into a prone position.
proximal, near to the central portion of the body.
ptosis, sagging of an organ to abnormally low position.
pulmonary, pertaining to the lungs.
pyo - prefix, pus.

radiology, science which deals with the use of radiant energy in the diagnosis and treatment of disease.
radium, radioactive element used in the treatment of disease.
radon, radium emanation.
radiolucent, relatively penetrable by X-ray.
ramus, a branch or process of a bone.
Reid's base line, line from the external canthus of the eye to the external auditory meatus.
renal, pertaining to the kidney.
reticular, having the appearance of network.
retro, prefix, meaning back or behind.
root mean square kilovoltage, the average effective kilovoltage of an alternating current.

sagittal plane, a plane dividing the body into right and left sides.
sarcoma, malignant connective tissue tumor.
sclerosis, pathological hardening of the tissues.
scoliosis, lateral curvature of the spine.
sella turcica, (turkish saddle), the saddle-like bone structure at the base of the skull which holds the pituitary gland.
semilunar cartilage (meniscus), cartilage of the knee for articulation with femoral condyle.
sesamoid bone, a bone formed in a tendon.
sigmoid, the "s"-shaped portion of the descending colon.
silicosis, disease of lungs due to inhalation of dust containing silica.
sine curve of an alternating current, its wave form.
six-hour meal, meal containing barium sulphate used to test motility of the gastro-intestinal tract.
skiagraph, old term used to indicate a radiograph.
spectrum, band of radiations formed by separation or dispersion of the various wave lengths of a hetereogeneous beam.
sphincter, circular muscle producing constriction or narrowing.
spine of a bone, a sharp outward projection.
spondylolisthesis, anterior slipping of a vertebra.
Sprengel's deformity, congenital anomaly involving the scapula.
stabilizer, appliance used in X-ray machines to render the milliamperage constant.
stellate, star-shaped.
stenosis, constriction of the lumen or opening of a canal.

stricture, a narrowing of the lumen by scar-tissue.
sub - prefix, meaning beneath.
Sudeck's atrophy, acute bone atrophy after an injury.
superior, above.
supination, "palm up" position of the forearm.
suppurate, to form pus.
supra - prefix, meaning above.
suture, line of union between bones of the skull.
symphysis, union of paired bones.
syndrome, symptom group or complex.
synovial membrane, joint membrane which secretes fluid.
systole, contraction stage of cardiac cycle.

tele - prefix, meaning at a distance.
teleroentgenograph, roentgenograph at six foot distance.
temporal, pertaining to the temple.
thorax, chest.
thymus, gland of internal secretion found in the supracardiac region; practically disappears after the second year.
tomograph, same as laminagraph.
torus fracture, folding or buckling fracture.
torsion, twisting.
transverse plane, a plane which divides the body horizontally at any level.
trauma, injury.
Trendelenburg Position, patient supine with head much lower than feet.
tubercle, or tuberosity, rounded projection of bones.
tumor, abnormal swelling; usually refers to a new growth.
turbinate bones, the scroll-like projections into the nasal cavity.

umbilicus, the navel.
ureter, tube connecting the kidney and bladder.
urography, radiographic examination of the urinary tract, usually employing contrast media.
uterosalpingography, radiography of the uterus and fallopian tubes employing contrast media.

varices, enlarged and tortuous (varicose) veins.
ventral, front.
ventriculography, radiography of the ventricles of the brain employing contrast media, usually air.
viscus, a body organ; such as the liver, spleen or kidney.

weight-bearing line, line indicating the direction of weight thrust.

xiphoid (ensiform) process, the small bony process forming the lower end of the sternum.

zygomatic arch, the bony arch which provides the prominence of the cheek bone.

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